

**A study of some factors which affect  
the perinatal mortality of lambs**

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# UNIVERSITY OF EDINBURGH

## ABSTRACT OF THESIS (Regulation 3.5.10)

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A survey of 47 commercially-managed flocks in South East Scotland revealed that during late gestation 62% (29 flocks) were classified, by mean flock serum 3-OH butyrate concentration, as adequately fed, 36% (17 flocks) as moderately underfed and one flock was severely underfed. There was a wide range in the lamb perinatal mortality rate from 2% to 15%. While the incidence of simple dystocia was between 15% to 30% of births, the prompt detection and correction of such events meant that lamb birth injuries did not result. Infectious disease was not the major cause of lamb mortality. Starvation, hypothermia and E. coli endotoxaemia caused by poor husbandry standards were the most important causes of high perinatal lamb mortality rates. There was no correlation between the lamb perinatal mortality rate and the level of dam nutrition during late gestation. Prematurity was an important cause of lamb deaths on some farms due to failure of the neonate to adapt to the extra-uterine environment. Cases of joint ill, spinal abscessation and meningitis occurred in certain flocks where management practices should have ensured adequate passive antibody transfer. In these flocks entero-invasion due to an overwhelming environmental challenge was considered to be the portal of entry for bacterial pathogens. Prophylactic oral antibiotics were necessary to control watery mouth in newborn lambs in 95% of flocks studied. Ewes carrying triplets were more susceptible to severe underfeeding during late gestation which resulted in a marked reduction in litter birthweights in approximately 30% of cases. Bovine colostrum feeding to weakly lambs proved to be an excellent supportive treatment in cases of inadequate dam colostrum production and no cases of bovine colostrum-induced anaemia were observed in these lambs.

**ABSTRACT**

Recent research work on perinatal mortality in lambs has concentrated on patho-physiological changes that occur during second stage labour. Poor placental development and low lamb birthweights which are related to dam nutrition during distinct stages of gestation are quoted as important factors contributing to an increased perinatal mortality rate. In addition, central nervous system haemorrhages caused by dystocia resulting in an increased lamb mortality rate have been reported by several workers. Rather than investigate existing poor husbandry standards on farms with average production figures, this study examined units with excellent production data in order to identify positive practices that could be recommended to other commercial farmers. This thesis is based on routine veterinary advisory work undertaken by the author in commercial flocks. The practical nature and further application of such work is emphasised throughout this thesis.

A survey of 47 commercially-managed flocks in South East Scotland revealed that during late gestation 62% (29 flocks) were classified, by mean flock serum 3-OH butyrate concentration, as adequately fed, 36% (17 flocks) as moderately underfed and one flock was severely underfed. Cases of ovine pregnancy toxæmia occurred in the severely underfed flock and the two moderately underfed flocks which contained individual ewes with serum 3-OH butyrate concentrations above 3.0 mmol/l. The occurrence of ovine pregnancy toxæmia cases was a poor indicator of overall moderate undernutrition in a flock. The mean ewe body condition score three to five weeks before lambing was not significantly correlated to the current level of nutrition within the flock and, therefore, the single assessment of condition score during late



pregnancy is not an accurate indicator of nutritional status of the flock at that time.

There was a wide range in lamb perinatal mortality figures which varied from 2% to 15%. Infectious disease was an uncommon cause of lamb mortality. There was no correlation between the lamb perinatal mortality rate and the level of dam nutrition during late gestation. The extent to which this relationship could be investigated was limited by the presence of only one severely-underfed flock in this study and the multifactorial nature of lamb losses. Prematurity was an important cause of lamb deaths on some farms due to failure of the neonate to adapt to the extra-uterine environment. The target number of lambs reared per 100 ewes mated should be in the region of 190 for lowground units.

Entero-invasion was considered to be an important route of infection in bacteraemic conditions. Omphalophlebitis associated with hepatic abscessation was not prevalent due to the attention paid to navel dipping. Cases of joint ill, spinal abscessation and meningitis occurred in certain flocks where management practices should have ensured adequate passive antibody transfer. In these flocks entero-invasion due to an overwhelming environmental challenge was considered to be the portal of entry for bacterial pathogens. Prophylactic oral antibiotics were necessary to control watery mouth in newborn lambs in 19 of 20 flocks studied.

Management factors such as environmental hygiene, level of flock supervision and dedication of the work force appeared to have a more direct effect on the perinatal lamb mortality rate. A level of



supervision of one full-time attendant per 120 sheep is recommended for the first two weeks of the lambing period when between 85 and 90% of ewes should lamb.

At Woodhouselea ewes carrying triplets were more susceptible to severe underfeeding than twin-bearing ewes on the same ration. Prolonged severe underfeeding of triplet-bearing ewes resulted in a marked reduction in litter birthweights. Such problems associated with triplet pregnancies brings into question the whole philosophy of improved nutrition (flushing) before mating time which attempts to increase the ovulation rate, implantation rate and litter size.

Fifteen of 184 (8.2%) twin-bearing ewes were severely underfed for a short period immediately prior to lambing but only two of the fifteen ewes produced low litter weights. Real-time ultrasound scanning should concentrate on identifying triplet pregnancies so that these sheep can be preferentially fed. There is an urgent need to cost high input/high output flocks (lambing percentage 190-195%) in respect of MLC recorded flocks and changes in the variable premium and ewe premium payments.

### RECOMMENDATIONS

The major objectives of this thesis were to evaluate the influences of late gestation nutrition of the dam, dystocia-related events such as intra-partum hypoxaemia and central nervous system haemorrhages on the lamb perinatal mortality rate. In this study dystocia was not a major contributing factor to the lamb perinatal mortality because of the high level of flock supervision and rapid detection of foetal malposition and malposture. Simple management factors were considered to have more direct effects on flock performance than intra-partum, patho-

physiological changes. A list of those practical recommendations which should be instituted on all lowground sheep farms is detailed below.

#### PRACTICAL RECOMMENDATIONS OF THIS STUDY

1. In this study the single most important factor responsible for achieving a low perinatal mortality rate was the provision of an adequate number of suitably trained and motivated staff. During the concentrated first two weeks of the lambing period one attendant per 120 sheep is recommended to ensure 24 hour per day flock supervision.
2. To ensure 85-90% of sheep lamb within the first two weeks of the lambing period, the ram to ewe ratio should be no greater than 1:30 with three or more rams run with a group of ewes. Ram breeding soundness examinations are strongly recommended.
3. Foetal numbers should be determined early in pregnancy by real-time ultrasound scanning. Triplet-bearing ewes should be managed preferentially from mid-pregnancy onwards.
4. Serum samples should be collected from representative animals in the triplet and twin-bearing ewe groups, four to six weeks before lambing, and assayed for 3-OH butyrate concentration. A target flock mean serum 3-OH butyrate concentration of 0.7 mmol/l is recommended.
5. A lambing pen of 1.6m x 1.6m dimensions is recommended for lowground ewes. Such pens must be well lit, suitably drained with cleaning and disinfection carried out between ewes. Continual usage with addition of straw between sheep is strongly condemned.
6. Navel dipping in strong veterinary iodine BP must be carried out at birth, four and eight hours later.

7. Administration of bovine colostrum, pooled from three or more cows, to weakly or hungry lambs by stomach tube within the first two hours of life is strongly recommended. All farm staff should be shown how to assess accurately prior colostrum intake of the lamb by trans-abdominal palpation of the abomasum.
8. Routine administration of oral antibiotics soon after birth to control watery mouth cannot be supported. Such a practice promotes poor husbandry standards and may predispose to other enteric infections a few days later. In this respect, a study of the prevalence of cryptosporidiosis in young lambs on such farms is overdue. A controlled study of the application of probiotics in the prophylaxis of watery mouth is needed.
9. A representative number of deaths that occur in lambs over one week old should be investigated as the majority of such deaths result from localisation of bacteraemic infections contracted during the first few hours of life.
10. Maintenance of accurate records provides invaluable information for further investigations.

**DECLARATION**

With the exception of the assistance and work described below the remainder of work reported in this thesis was undertaken by myself.

Mr A Dowell, Dalgety Laboratory, R(D)SVS analysed the blood samples collected at the routine veterinary visits to the flocks in this study.

Cerebrospinal fluid analyses were performed by members of the Clinical Pathology Laboratory, R(D)SVS.

Examination of ovine abortion material was undertaken by members of the Edinburgh Veterinary Investigation Centre.

At Woodhouselea the recording of ewe liveweight and condition scores and lamb birthweights were carried out by farm staff.

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Blood sample analyses were performed by Mr A Dowell, Dalgety Laboratory, R(D)SVS. Cerebrospinal fluid analyses were carried out by members of the Clinical Pathology Laboratory, R(D)SVS.

I am grateful to the farm staff at Woodhouselea Farm and members of the Genetics and Animal Breeding Science (GABS) section of the Scottish Agricultural College. Dr J E Vipond designed the statistical package used to analyse these data.

## 2.0 INTRODUCTION

Progressive cut-backs in the sheep variable premium during 1990 and 1991 have led to a marked reduction in returns to sheep producers for lambs, breeding stock and cull ewes. The complete removal of the variable premium in 1992 makes the market situation even more uncertain. As feeding stuffs are the major component of variable costs in lowground units, this input is an area which is constantly under review by sheep producers operating intensive production systems. While the effects of underfeeding during late gestation have been researched on experimental units and excellent guidelines established, the prevalence and consequences of moderate or severe underfeeding in commercial sheep flocks have not been so thoroughly investigated.

Economic analysis of flocks in the Meat and Livestock Commission (MLC) Flock Health Scheme (MLC Yearbooks 1988, 1989, 1990, 1991) has consistently demonstrated that stocking density at pasture is the single most important factor influencing farm profitability and accordingly advice is largely based on improving this area of management. High stocking rates and reliance on compound fertilisers has been the trend over the past decade. Unfortunately, the MLC data analysis has one critical flaw in that the results are based on well-managed flocks which do not set sufficiently demanding standards for sheep producers. Within such a sample, analysis has failed to focus management inputs on areas other than pasture management in an attempt to increase financial returns. Experience gained by the author during ten years in farm animal practice has shown that in certain flocks the number of lambs sold per 100 ewes mated can be 20%-25% greater than MLC recorded flocks.

One of the aims of this study was to investigate the management policies of some high producing flocks and to compare these production data with those of MLC recorded flocks. Such analysis would identify positive management policies rather than the usual problem-orientated single flock approach.

While computer ration formulation and metabolic profile testing of dairy cows have been used to considerable advantage by milk producers in the United Kingdom (Kelly and Whitaker, 1984) such preventive medicine programmes have not been widely adopted by the veterinary profession for sheep nutritional advice despite excellent practical guidelines (Russel, 1985).

The role of dystocia has been reported as a major contributing factor to a high lamb perinatal mortality (Wilsmore, 1986, 1989) but only one flock was studied. The study by Barlow, Gardiner, Angus, Gilmour, Mellor, Cuthbertson, Newlands and Thompson (1987) implied that pathophysiological changes, particularly during second stage labour, result in a lamb perinatal mortality rate of approximately 10% which would be largely unaffected by management control factors. Such reports appear to contradict the situation which is commonly encountered in general veterinary practice whereby dystocia is predominantly caused by simple foetal malposture, malpresentation or malposition and if detected promptly can be simply corrected.

The aims of this work were:

1. to identify the major causes of perinatal lamb mortality and make recommendations for the control of such losses;

2. to investigate the role of dystocia in the aetiology of lamb perinatal mortality.
3. to determine the incidence of energy underfeeding in low-ground flocks during late gestation and to investigate the relationship between level of dam nutrition and flock performance. To determine the incidence of ovine pregnancy toxæmia and to investigate management factors which may be involved in the aetiology of this common metabolic disease;
4. to establish realistic target production characteristics for lowground sheep flocks.



## **LITERATURE REVIEW**

### **3.1.1 DEFINITION OF THE PERINATAL PERIOD**

For the purposes of this study the perinatal period has been defined as the period from the onset of first stage labour to three days of age. First stage labour begins with the initial uterine contractions and ends with cervical dilation (Arthur, 1973). Lambs born less than day 140 of gestation were excluded from this study. Lambs born between 140 days and 147 of gestation have been defined as premature. In many commercial flocks ram keels are changed only every 7 to 10 days during the service period, therefore this definition of prematurity cannot always be strictly applied.

This definition of perinatal mortality excludes the majority of lambs lost during the last six weeks of pregnancy caused by the common abortifacient agents; Chlamydia psittaci var ovis, Toxoplasma gondii, campylobacter spp. and salmonella spp (VIDA, 1986). However some of these agents, namely: C. psittaci (Linklater, Low and Hosie, (1987); T. gondii (Turner, Mohammed and Savva, 1991), in addition to border disease virus (BDV) (Nettleton, 1988), can result in the birth of stillborn or weakly lambs from a normal length pregnancy. Therefore, it is possible in some flocks that these congenitally-acquired infections can significantly contribute to the lamb perinatal mortality rate.

### **3.1.2 PERINATAL MORTALITY RATES**

In the United Kingdom the annual perinatal lamb mortality rate has been quoted as 15% or greater by numerous studies (Stamp, 1967; Whitelaw, 1976; Eales, Small and Gilmour, 1982, 1983; Barlow, Gardiner, Angus, Gilmour, Mellor, Cuthbertson, Newlands and Thompson, 1987). Annual lamb

mortality figures as high as 25% have been quoted (Hindson and Winter, 1990) who also state that 90% of total lamb losses occur in the perinatal period. In the United States lamb perinatal mortality accounts for between 15-20% of the potential annual lamb crop (Stafford and Hoversland 1960; Gates, 1977), although such records are often limited to test centres and University experimental stations. It is possible that the perinatal mortality could be higher on commercial enterprises. Lamb mortality reports consistently demonstrate a pattern of perinatal losses ranging from 10-35% of the annual lamb crop (Rook, Scholman, Wing-Proctor and Shea, 1990). In Australia, lamb perinatal mortality rates between 17 to 35% have been quoted (Dennis and Nairn, 1970; Haughey, 1985).

In the United Kingdom the flock recording schemes operated by the Meat and Livestock Commission (MLC) provide comprehensive performance figures for approximately 350 lowland sheep flocks. Unfortunately, these data are likely to be biased as participants in such a service are more progressive and better informed than the average sheep farmer and would be expected to produce correspondingly better performance figures. Even with such a subjective proviso the lamb perinatal mortality of these flocks is still in the region of 12-15% (MLC Yearbooks 1987, 1988, 1989, 1990). The high stillborn rate reported in these surveys has been questioned (Hindson and Winter, 1990) who state that lamb perinatal mortality rates above 8-10% indicate, in all probability, poor flock supervision and that with 24 hour surveillance of the flock this rate could be reduced to 1-2%. Rook et al. (1990) suggested that reducing lamb perinatal mortality from 15-20% to less than 5% should be a realistic goal for all producers.

In recent single flock studies a perinatal lamb mortality rate of 5.5% was reported (Safir, 1991). Despite this low perinatal lamb mortality rate, only 158 lambs were reared per 100 ewes mated. With a litter size of 2.0 these figures indicate substantial losses in lambs more than one week old. A perinatal lamb mortality rate of 6.5 to 7.0% has been reported by Trower (1991).

### **3.1.3 LOSSES DUE TO INFECTIONS CONTRACTED IN THE PERINATAL PERIOD**

During the first few days of life bacterial infection via the umbilical vessels and/or entero-invasion can result in septicaemia and rapid death. With less severe bacterial invasion a bacteraemia may develop with localisation of infection producing debilitating diseases which may cause high mortality rates some days to many months after the localised infection became established. Despite the fact that the infectious agents gain entry during the neonatal period the resultant losses are not recorded in perinatal mortality figures. Infections such as joint ill (suppurative polyarthrititis), meningitis and endocarditis can cause significant losses in older lambs but should be attributed to deficiencies in flock management during the lambing period.

Bacterial contamination of the umbilical vessels within the first few hours after birth results in omphalophlebitis and a possible bacteraemia. Venous drainage via the portal system to the liver may result in hepatic abscessation. The characteristic appearance of umbilical cord infection with contiguous spread to the liver is that of hepatic necrobacillosis. Further bacteraemic spread to involve primarily the joints, meninges and endocardium is uncommon.

In calves a bacteraemia may also result from entero-invasion by organisms across the small intestine mucosa (Rings, 1987) and is attributed to the ingestion of large numbers of bacteria. This bacterial challenge is associated with unhygienic environmental conditions at calving time. The subsequent development of a septicaemia is facilitated by failure of passive antibody transfer (Gay, 1965). It is postulated that septicaemia in the neonate is associated with an agammaglobulinaemic state whereas hypogammaglobulinaemia results in a bacteraemia. E. coli is the pathogen most commonly isolated from septicaemic and bacteraemic lambs (Eales, Small, Gilmour, Donachie, Fitzsimons and Dingwall, 1986) with the joints and meninges (Mosher, Helmboldt and Hayes, 1968; Rings, 1987) the common sites of infection. A bacteraemia which occurred within hours of birth can develop slowly as a bacterial vegetative endocarditis lesion with death resulting months later.

#### **3.1.4 THE ROLE OF MANAGEMENT FACTORS IN THE AETIOLOGY OF PERINATAL LOSSES**

Despite the fact that almost twenty years ago it was suggested that 70% of all lamb losses are caused by management factors and not by infectious disease (McKenzie and Grant, 1976), little progress appears to have been made since that time. No recommendations for farm staffing during the busy lambing period could be found in the literature although Eales (1985) reports that many farmers would not have adequate labour to treat thoroughly more than a few lambs suffering from watery mouth. In 1984 in the United Kingdom it was estimated that the annual lamb mortality rate was between two and four million and that most of these losses were not due to infectious diseases.

In New South Wales an improvement of only 9% in lamb weaning percentage has been achieved over the thirty year period 1951-1981 (Haughey, 1985). In the United States of America, workers have reported that infectious agents are often secondary and opportunistic to management-related problems and that emphasis appeared to be targetted to areas of research and education that have little impact on lamb perinatal mortality (Rook et al., 1990).

Under Australian farm management conditions at least 80% of neonatal deaths fall into two categories: those where death occurs during or within a few hours of dystocia and those comprising the starvation, mismothering, exposure complex (Haughey, 1985). Losses from each of these categories should be readily controlled by correct management and supervision of the flock.

### **3.1.5 CONGENITAL ABNORMALITIES**

The incidence of congenital abnormalities is low affecting only 0.5-2.0% of lambs, of which 50% of the defects are visible externally (Dennis, 1985). Such congenital abnormalities rarely contribute to major perinatal lamb losses (Rook et al., 1990).

### **3.2.1 ABORTION**

In New Zealand the influence of foetal and or placental infection on the perinatal lamb mortality rate is considered to be small (Gumbrell, 1985). In an extensive survey of Michigan flocks (Rook et al., 1990), 16.5% of preweaning lamb losses resulted from abortion but these losses were not evenly distributed, instead they involved severe, isolated outbreaks of abortion on individual farms. A similar epidemiology is reported for S. montevideo in Scottish flocks (Linklater, 1983) and in

New Zealand for campylobacteriosis (Gumbrell, 1985). The abortifacient agents which may result in perinatal loss due to stillbirths or the birth of small weakly lambs after a normal length of gestation are described below.

### 3.2.2 BORDER DISEASE VIRUS

Clinical cases of Border Disease are only occasionally reported despite a high prevalence of serum neutralising antibody in those flocks surveyed (Sands and Harkness, 1978). The epidemiology of Border Disease virus (BDV) infection has been described in detail (Nettleton, 1988). Clinical signs at birth are those of cerebellar dysfunction and proliferation of secondary guard fibres (Shaw, 1984). A provisional diagnosis is based on clinical examination of affected lambs and confirmed by virus isolation from blood samples of affected lambs. An increased lamb perinatal mortality rate has been associated with BDV infection in a flock where classical clinical signs of "hairy shakers" were absent (Bonniwell, Nettleton, Gardiner, Barlow and Gilmour, 1987). Therefore, the consequences of BDV infection in the offspring of susceptible pregnant sheep may be more important than previously thought and it may be worthwhile considering virus isolation screening for BDV if unexplained losses occur in young lambs.

### 3.2.3 TOXOPLASMA GONDII

Toxoplasmosis is the second most commonly diagnosed form of ovine abortion (Clarkson, 1987). In addition, Johnston (1988) postulated that in some of the flocks studied the high barren rate of approximately 6-8% could in part be the result of T. gondii infection of susceptible sheep during the first 40 days of pregnancy leading to foetal loss. This figure compares with a barren rate in the national flock of 4% (MLC

Yearbooks 1989, 1990). The consequences of T. gondii infection depend upon the stage of embryo/foetal development when infection of a susceptible sheep occurs. There is sequentially foetal loss, abortion and the birth of weakly lambs (Blewett and Trees, 1987). Diagnosis of toxoplasmosis is best performed by demonstrating dam seroconversion one week post abortion (Buxton, Blewett, Trees, McColgan and Findlayson, 1988). The extent to which the birth of weakly lambs, as a consequence of late T. gondii infection, contributes to an increased perinatal lamb mortality rate is unknown. A perinatal lamb mortality rate of 53% associated with low birthweight triplet lambs was thought to be the result of toxoplasmosis (Khalaf, Doxey, Baxter, Black, Fitzsimons and Ferguson, 1979b) but serological examination of the dams was not conclusive.

The importance of foetal T. gondii infection as a contributory cause of perinatal lamb mortality has been highlighted by a recent study. The presence of T. gondii infection in tissue was investigated using the polymerase chain reaction (PCR) (Wheeler, Wilmore, Savva and Turner, 1990). From a total of 41 samples of brain tissue 32 (78%) were found to be positive for the presence of T. gondii DNA (Turner et al., 1991). The authors interpret such findings as the explanation for central nervous system dysfunction manifest by sucking, vision and locomotor problems in lambs from some flocks with an active T. gondii infection. Furthermore, the presence of T. gondii infection in a flock of pregnant sheep can manifest itself in a variety of forms including foetal resorption, abortion, stillbirth and even death of full-term lambs within a few days of birth (Turner et al., 1991). These authors further report the death of four lambs in the perinatal period could be attributed to congenitally acquired T. gondii infection yet such lambs



appeared clinically normal at birth and had normal siblings (Turner et al., 1991). Further application of this recent technology may indeed reveal a higher prevalence of congenitally acquired T. gondii in neonatal lambs than was previously thought.

The small survey of Wheeler et al. (1990) highlights the shortcomings of the current serological investigation methodology for the routine investigation of ovine abortion material for T. gondii compared to PCR results. These results (Wheeler et al., 1990) should be borne in mind when interpreting the detailed results of lamb perinatal mortality studies where only one flock was surveyed. For example, could congenitally acquired T. gondii infection explain some of the results reported by Barlow et al. (1987)?

T. gondii infection was possibly the cause of a very high (53%) perinatal mortality rate in low birthweight triplet lambs (Khalaf et al., 1979b). In the study (Khalaf et al., 1979b) lamb birthweight may have been of secondary importance compared to T. gondii-induced central nervous system pathology. Until PCR technology is readily available to investigators there is a need to include a large number of flocks within a survey to reduce the risk of undetected T. gondii infection in some of the sample flocks contributing significantly to the perinatal lamb mortality rate.

Preventive measures for controlling toxoplasmosis using epidemiological data have been outlined (Faulk, Clarkson and Winter, 1986). In many flocks an attempt is made to reduce placental and foetal toxoplasma infection by including monensin sodium at a daily rate of 10mg/head in the daily concentrate ration for the last 70 days of gestation. Such a



prophylactic strategy has been shown to protect ewes against experimental challenge with T. gondii oocysts (McColgan and Buxton, 1986).

#### 3.2.4 CHLAMYDIA PSITTACI

The abortion of fresh foetuses during the last three weeks of pregnancy is a common sequel to Chlamydia psittaci var ovis infection (Aitken, 1987). The typical epidemiology is that of infection acquired from infected placentae or uterine discharges during one lambing period with abortion during the following pregnancy (Aitken, 1987). If infection is acquired during early pregnancy abortion may result during that same pregnancy although there is debate about the minimum time between infection and abortion: six weeks (Aitken, Clarkson and Linklater, 1990) and 69 days (Blewett, Gisemba, Miller, Johnson and Clarkson, 1982). From a practical standpoint, the compact lambing period of lowground flocks reduces the significance of such epidemiology.

C. psittaci infection causes a necrotising placentitis which limits the exchange of nutrients and metabolites between dam and developing foetuses. During the second half of pregnancy the placenta is the major site for progesterone production and the progressive chlamydial placentitis can significantly reduce progesterone synthesis (Aitken, 1987) and abortion results. In less severe cases chlamydial infection results in the birth of stillborn or weakly lambs which can suffer a high perinatal mortality rate (Andreani, Poli, Tolari, Carri, Farina and Bandecchi, 1987; Linklater et al., 1987).

Attempts to limit the effects of C. psittaci infection within a flock have concentrated on vaccination and the use of strategic antibiotic

treatments. The beneficial use of the C. psittaci A22 strain has been questioned (Linklater and Dyson, 1979) because the abortion rate caused by C. psittaci was not significantly different between vaccinated and control flocks. The incorporation of C. psittaci strain S22/3 into the vaccine resulted in a significantly lower perinatal lamb mortality rate in the vaccinated group compared to controls, 10.8% compared to 20.4%. The perinatal lamb mortality rate of 10.8% (Linklater et al., 1987) is still higher than target values of less than 5%.

The beneficial response to strategic long-acting oxytetracycline injections during late pregnancy in C. psittaci infected flocks was first reported by Rodolakis, Souriau, Raynaud and Brunault (1980). A significant reduction in the number of abortions caused by C. psittaci infection occurred in oxytetracycline-treated groups compared to within flock control groups (Brodie, Duncan and Harvey, 1983; Greig, Linklater and Dyson, 1985).

### 3.2.5 CAMPYLOBACTER SPECIES

Campylobacteriosis due to Campylobacter fetus fetus and Campylobacter jejuni are the most common forms of bacterial abortion accounting for 6-15% of outbreaks (Greig, 1987). Abortion occurs following foetal infection and aborted lambs are generally dead.

### 3.2.6 SALMONELLA SPECIES

Of the many salmonella serotypes that can cause ovine abortion, S. montevideo is numerically the most important. Infection results in septicaemia of the dam with subsequent abortion (Linklater, 1983). With such an epidemiology S. montevideo infections are unlikely to result in

significant lamb perinatal losses although the ewe death rate is usually high, causing serious financial loss.

### 3.2.7 LEPTOSPIRA INTERROGANS SEROVAR HARDJO

Leptospira interrogans serovar hardjo has been recovered from aborted lambs and immunofluorescence evidence of its possible involvement in late term abortion and stillbirth has been reported (Ellis, Bryson, Neil, McParland and Malone, 1983). However, no further outbreaks of late abortion in ewes caused by serovar hardjo have been reported since that time.

### 3.3.1 OVINE PLACENTATION

The sheep has a uterus bicornis and a multiple pregnancy is normal in most breeds. The ovine placenta is of the epitheliochorial cotyledonary type (Bjorkman, 1970).

### 3.3.2 PLACENTAL DEVELOPMENT

The cotyledonary portion of the placenta contributes about 80% to the weight of each placentome (Mellor and Murray, 1981) and can be used as an index of placental size (Mellor, 1983). In the sheep, as in other mammals, there is a high degree of correlation between birthweight and placental weight (Naaktgeboren and Stegeman, 1969). As the foetus is totally dependent on the placenta for nutritive exchange any reduction in this process, whether caused by reduced placenta weight, number of cotyledons or placental infection, will adversely effect the birthweight and survivability of the neonate. Placental weight was the greatest single source of variation in the weight of the foetus at term, accounting for 69-91% of the variance (Mellor, 1983).

The total amount of functional uterine tissue available for embryo attachment is of primary importance in determining placental mass (Stegeman, 1974). In studies where embryos of the same breed were transferred to a variety of other breeds, uterine environment rather than embryo genotype significantly influenced growth of the foetuses (Hunter, Adams and Rowson, 1954).

The total weight of the cotyledons reaches a maximum after 80-90 days (Davies and Wimsatt, 1966; Stegeman, 1974) at which stage the foetus(es) have reached 25% of ultimate birthweight (Naaktgeboren and Stegeman, 1969). The general recommendation (Boundy, 1985) that because dam energy requirements are little more than maintenance during the second and third months of pregnancy, this is an appropriate period to slim down overfat ewes is unsupported by experimental data. In fact, undernutrition during mid pregnancy may result in reduced placental development and increased foetal death (Mellor, Mitchell and Matheson, 1977). The total weight of cotyledons per foetus decreases by about 12% for each increase in the number of foetuses, as compared with a 20% decrease in number of cotyledons but only a 7 to 11% decrease in the weight of the individual foetuses (Rhind, Robinson and McDonald, 1980). With a limited number of caruncles the compensatory hypertrophy of individual placentomes occurs before about 90 days of gestation (Mellor et al., 1977a).

In studies of Texel sheep the average weight of foetal membranes varied from 450 to 710 grams (Stegeman, 1974). The number of cotyledons is fixed at the time of placental formation and remains constant throughout gestation with the number of cotyledons for each foetus being inversely related to litter size (Stegeman, 1974). In a single pregnancy there

are about 70 cotyledons with the pregnant horn containing the majority (Alexander, 1964). In twin pregnancies the number of cotyledons in each horn averages about 45 (Stegeman, 1974). In a triplet pregnancy one horn contains two foetuses but the placenta of one of these foetuses extends into the other horn. In a triplet pregnancy the number of caruncles and corresponding cotyledons may exceed 100 (Stegeman, 1974).

### **3.3.3 GROWTH OF FOETAL MEMBRANES**

Reduced placental development is reported to occur in a small proportion of ewes in most flocks evident as retarded foetal growth (Mellor and Murray, 1981, 1982a; Mellor, 1983). Poor placental development results in foetuses of low birthweight and because of impaired placental exchange these foetuses also exhibit chronic hypoxaemia with an elevated haematocrit, increased plasma lactate concentration, chronic hypoglycaemia and reduced concentrations of plasma insulin and other hormones including thyroxine and prolactin (Barlow et al., 1987).

Foetal death is reported to be common when placental weight is below normal (Mellor et al., 1977a) and is considered to be the result of impaired oxygen and nutritive exchange (Mellor, 1983). A reduction in lamb birthweight of 30% resulted from experimental disruption of uterine vascular supply to the caruncles which became fibrotic (Creasy, Barrett, de Swiet, Kahampaa and Rudolph, 1972). The influence of placental weight on lamb birthweight is greater than that of the sex of the foetus (Naaktgeboren and Stegeman, 1969; Stegeman, 1974).

Reduced placental function can also produce a chronic hypoxaemic state in the foetus (Eales and Small, 1980a; Barlow et al., 1987) which reduces the newborn lamb's thermogenic response to cold stress (Eales

and Small, 1980a, 1985). This impaired thermogenic response increases the susceptibility of the neonate to hypothermia and eventual death if left untreated (Eales and Small, 1980b; Eales, Gilmour, Barlow and Small, 1982; Barlow et al., 1987).

Mellor (1983) observed that lambs are also at risk when the total placental weight is near the top of the normal range. In this situation Mellor (1983) postulates that high foetal energy demands may cause severe maternal undernutrition resulting in an increased incidence of pregnancy toxemia and dystocia. While dam undernutrition may result in deleterious effects on foetal birthweight, there are no experimental data to suggest that high placental weight will necessarily cause increased foetal weight thereby increasing energy demand by the foetus and so result in ovine pregnancy toxemia. Similarly, it is difficult to accept the postulate that an apparently obvious solution to a high mortality rate among low birthweight lambs is to maximise placental growth by improving maternal nutrition during the first few months of pregnancy (Mellor, 1983). Firstly, it has not been shown conclusively that low birthweight lambs have a significantly higher mortality rate. Secondly, improved nutrition during mid pregnancy may result in overfat ewes which, if followed by a prolonged period of moderate to severe undernutrition, may predispose to ovine pregnancy toxemia. Thirdly, the metabolisable energy requirements of ewes during the second and third months of gestation are only marginally above maintenance figures. It is probable that sufficient energy would be supplied from grazing and provision of hay during adverse weather conditions.

While fusion between adjacent allantoic membranes does occur placental blood vessel anastomoses are rarely found in sheep (Steen, 1968;

Stegeman, 1974). The expulsion of foetal membranes from a multiple pregnancy which have fused may cause difficulties when attempting to correlate placental weight to lamb birthweight.

### **3.3.4 VARIATION IN LAMB BIRTHWEIGHTS**

Within-litter variation in the birthweight of lambs from prolific ewes may largely reflect variation in their abilities as embryos to compete for attachment points on the endometrium (Dingwall, Robinson, Aitken and Fraser, 1987). In late pregnancy it has been shown that the compensatory increase in cotyledon weight is insufficient to correct impaired foetal growth caused by a deficiency in numbers of cotyledons (Rhind et al., 1980). However, it must be remembered that although the placenta is not changing in weight during late pregnancy there are important functional changes (Stegeman, 1974).

### **3.4.1 LITTER SIZE AND BIRTHWEIGHTS**

The mean ratio of birthweight of individual twin lambs to singletons can be calculated as 0.80 and the corresponding reduction from twins to triplets as 0.77 (Donald and Russell, 1970). The total weight of the gravid uterus at parturition when it contains twins, triplets and quadruplets is 20, 27 and 33% of the bodyweight of the ewe at mating (Robinson, McDonald, Fraser and Crofts, 1977). The interspecies relationship between total foetal weight and maternal weight at mating (Leitch, Hytten and Billewicz, 1959) indicates that a ewe weighing 70kg will produce foetus(es) with a total birthweight of 5.8kg. Prolific ewes exceed this value by 1.5 - 2.4 times. These data led Robinson et al. (1977) to conclude: "it may be that these physical load forces should be given greater consideration when attempts are made to increase the prolificacy of sheep and that the optimum number of lambs to be



produced in a single pregnancy is less than the maximum that can be produced under ideal conditions". The number of lambs can only be increased if the weights of the individual lambs is correspondingly reduced.

#### **3.4.2 FACTORS INFLUENCING LITTER SIZE**

While ovulations were randomly distributed between the ovaries, migration of embryos between the two horns contributes to a more even uterine distribution (Rhind et al., 1980). An increase in the ovulation rate was associated with increased foetal mortality resulting in a disparity in distribution of remaining fetuses (Rhind et al., 1980). The presence of some very small lambs in large litters should not be attributed solely to maternal undernutrition during late pregnancy (Rhind et al., 1980) as reduced placental nutrient exchange may take place to those fetuses.

#### **3.4.3 REAL TIME ULTRASOUND SCANNING**

While real-time ultrasound scanning is a reliable means of predicting pregnancy, the accuracy in predicting litter size: singles 89% twins 87% and triplets 68% in the study conducted by Harding, Joby and Hardy (1984) is disappointing.

#### **3.4.4 HORMONAL CONTROL OF FOETAL MATURATION AND PARTURITION**

It is imperative for the survival of the newborn lamb that it is able to find the ewe's teat and suck adequate quantities of high quality colostrum within the first six hours after birth (Mellor and Murray, 1986). The physiological mechanisms which control the change from foetal quiescence (Walker, 1984) to physical activity of the newborn are incompletely understood (Mellor, 1988).



Foetal plasma progesterone concentrations decrease and oestrogen concentrations increase before birth (Challis and Lye, 1986). As progesterone injections suppress and oestrogen injections stimulate physical and respiratory activity in hysterotomy-derived lambs (Mellor, McKay and Williams, 1972), the change in these hormone concentrations during late gestation would appear to facilitate the transition from quiescence to physical activity. Studies in calves have revealed that cortisol concentrations which are responsible for normal pulmonary, intestinal and central nervous system development (Breazile, Vollmer and Rice, 1988) double within a few minutes of birth (Comline and Silver, 1972).

The marked temperature fall from the controlled in-utero existence to prevailing environmental temperature is another factor which stimulates physical activity in the newborn (Mellor, 1988). Experimental reduction of amniotic fluid temperature resulted in deep, regular breathing of the foetus (Gluckman, Gunn and Johnston, 1983); conversely active neonatal lambs assumed a somnolent attitude when immersed in a waterbath held at 39°C (Eales and Small, 1980a, b).

### **3.5.1 IMMUNITY**

Although all the components of the immune system are present in the neonate at birth, adult levels of immune competence are not reached until 30 days old (Banks and McGuire, 1989). Pre-colostral complement concentrations are only 12-60% of adult levels (Renshaw and Everson, 1979) and are increased following ingestion and absorption from colostrum (Stoneham, Wingfield Digby and Ricketts, 1991). The neonate, however, will not receive antibody to specific microorganisms unless the

dam had previously been exposed to them and produced an appropriate immune response (Stoneham et al., 1991).

### 3.5.2 PASSIVE ANTIBODY TRANSFER IN LAMBS

Resistance to specific infections of the lamb can be afforded by appropriate vaccination of the dam and the passive transfer of colostral immunoglobulins (Campbell, 1974, Snodgrass and Wells, 1978, Mellor and Murray, 1986). Routine vaccination programmes presently operated by farmers in the United Kingdom are concerned with the control of certain clostridial diseases, only one of which, lamb dysentery, occurs during the perinatal period. Under experimental conditions Halliday (1968, 1970 and 1976) related lamb perinatal mortality to serum immunoglobulin concentrations. Similar results from field studies have also been reported (Harker, 1973). Passive antibody transfer via immunoglobulins in colostrum during the first hours of life is essential for lamb survival. This fact is well demonstrated by the study (Eales, 1985) whereby all colostrum-deprived lambs developed watery mouth when challenged experimentally whereas all colostrum-dosed lambs survived.

Almost one third of ewes on a low plane of nutrition during pregnancy failed to produce sufficient colostrum for their lambs (Khalaf, Doxey, Baxter, Fitzsimons and Ferguson, 1979a) compared to adequate colostrum supplies from well-fed ewes. Similar trends between underfeeding and poor colostrum accumulation in the udder have been reported from other studies (Treacher, 1970; Louca, Marrogenius and Lawlor, 1974).

Studies involving well-nourished sheep (Strubber, Doxey, Black and Fitzsimons, 1979a) failed to establish a clear relationship between the amount of colostrum consumed and the concentration of immunoglobulin in

the lamb's circulation. Further work suggested that by 30 hours of age the low percentage of ingested immunoglobulin present in the serum was the result of usage or redistribution within the body during this period (Strubber, Doxey, Black and Fitzsimons, 1979b). Such redistribution of passively-derived immunoglobulin may influence the interpretation of serum immunoglobulin concentrations collected in practical situations and used as a guide to colostrum uptake by the newborn lamb. In addition, whilst serum immunoglobulin concentrations indicate the acquisition of passively-derived antibody, colostrum also acts as an essential energy source and has valuable laxative properties. Therefore, any relationship between the perinatal mortality rate and serum immunoglobulin concentration may not be restricted to susceptibility to infection. For example, in the case of watery mouth, the lack of the physical laxative effect of colostrum could be as important as failure of immunoglobulin transfer.

In their investigations of perinatal lamb mortality, Khalaf et al. (1979b) reported lambs with low serum concentrations of IgG and IgM will often survive if food supplies become available and only when combined immunoglobulin concentrations are less than 10g/litre at 24 hours old can serum immunoglobulin concentration and lamb mortality be directly correlated.

Mellor (1988) stated that as not all colostrum-deprived lambs succumb to infection, some are born with an inherent resistance to some pathogens although this statement is not supported by experimental data.

### 3.5.3 COLOSTRUM SUBSTITUTES

A shortage of ewe colostrum is reported to be common in many flocks (Winter, 1987). This shortage of ewe colostrum has resulted in the widespread use of cow colostrum as a substitute.

In Holland the control of maedi-visna infection within a flock includes weaning of newborn lambs before they suck colostrum from their dam to prevent the transfer of lentivirus. Cow colostrum has been used as a substitute for dam colostrum but is claimed to result in an overall incidence of anaemia in young lambs of 4%, but there is considerable variation with some flocks experiencing 20% of lambs affected, many of which died if untreated (Winter, 1987). The exact incidence of cow colostrum-induced anaemia in young lambs in the United Kingdom is unknown although there are reports of individual or small numbers of lambs so affected (Gray, 1983; Inglis, 1983; Stubbings, 1983).

### 3.5.4 STUDIES OF PASSIVE ANTIBODY TRANSFER IN FOALS

In thoroughbred foals the incidence of failure of passive antibody transfer defined as serum IgG concentrations less than 4.0g/l varies between 15% (Stoneham et al., 1991) and 24% (Crawford, McGuire, Hallowell and Macomber, (1977)).

Reports that indicate an increased incidence of neonatal infections in foals as a consequence of failure of passive transfer (Koterba, Brewer and Tarplee, 1984; Brewer and Koterba, 1985) have been questioned by the results of a recent study (Baldwin, Cooper, Vanderwill and Erb., 1991). McGuire, Poppie and Banks (1975) observed that 78% of foals suffering from complete failure of passive antibody transfer required treatment for infectious disease during the neonatal period. However a recent

report (Stoneham et al., 1991) describes infectious disease in foals despite plasma transfusions. The failure of plasma transfusions to protect foals against neonatal infection may be the result of the delay in their administration to the newborn foal or the failure of circulating immunoglobulins to protect against localised infections in the gut. Furthermore, Baldwin et al., (1991) reported that all their hypogammaglobulinaemic foals survived without the need for plasma transfusions.

The conclusion that is drawn from these data is that while serum IgG concentration provides a broad measure of immunity to the neonatal foal, a severe bacterial challenge to the foal, or bacteria to which the dam has had no previous contact, can cause a bacteraemia in the foal with subsequent localised infections in the joints, parenchymatous organs and meninges.

### **3.6.1 POSTPARTUM LAMB LOSSES**

The standard classification of prenatal, natal and postnatal mortality (Rook et al., 1990) indicate that the majority (>60%) of lamb losses occur in the early postpartum period (Dennis, 1972; Whitelaw, 1976; Purvis, Ostler and Starr, 1979; Johnson, MacLachan and Murray, 1980).

The best method of confirming the cause(s) of perinatal losses is by gross post mortem examination performed on a representative number of lambs (Rook et al., 1990). The common causes of perinatal lamb mortality, many of which are inter-related, are reviewed below.

### 3.6.2 HYPOTHERMIA

Between 30-50% of post-partum lamb losses are caused by hypothermia resulting from either starvation, chilling or a combination of both factors. Failure to suck and heat loss due to adverse weather conditions form part of the dystocia, starvation, mismothering, exposure complex (Hindson and Winter, 1990; Rook et al., 1990). The role of dystocia in the aetiology of hypothermia is described in detail later in this section. Diagnosis of the starvation, mismothering, exposure complex, based on the interpretation of rate and extent of perirenal fat mobilisation at necropsy, has been expertly described by Rook et al (1990).

Hypothermia and starvation are influenced by a large number of management factors including the prevailing weather conditions, the provision of shelter and quality of flock supervision. The fact that most lambs die within the first 24 hours of life should suggest to farmers that concentrating management practices and labour on at-risk lambs during the first day of life can be a major factor in the reduction of neonatal mortality (Rook et al., 1990). Low birthweight lambs are considered to be particularly susceptible to hypothermia (Slee, 1976, 1978; Sykes, Griffiths and Slee, 1976; Huffman, Kirk and Pappaionou, 1985).

The deleterious effects of hypoxaemia on heat production capacity were only observed in lambs with severe acidaemia (Eales and Small, 1985) and it is possible that the mild acidaemia commonly found following normal parturition is not associated with adverse effects on thermogenesis. These observations prompted Eales and Small (1985) to suggest that the only treatment required for lambs which had suffered severe hypoxia

during delivery is warmth to prevent hypothermia and sufficient time in such an environment to facilitate self-correction of the base deficit.

### **3.6.3 COLOSTRUM AS AN ENERGY SOURCE**

Inadequate colostrum intake during the first 6 to 12 hours of life leads initially to hypothermia and then a progressive hypoglycaemic and hypothermic state develop (Mellor and Murray, 1985a). While colostrum feeding is essential to provide passively derived immunoglobulins to hypothermic lambs that have not sucked, supplemental heat is critical to reverse the excessive loss of body temperature that has also occurred (Rook et al., 1990).

### **3.6.4 HYPOGLYCAEMIA**

In young lambs the hypoglycaemia associated with presenting clinical signs of coma can be pronounced with plasma glucose concentrations below 1.0 mmol/litre compared to 4-8 mmol/litre for adequately fed lambs (Eales et al., 1982a, b). It is essential that comatose lambs receive an intraperitoneal injection of dextrose prior to being placed in a warming box or else increased muscular and nervous system activity in association with the profound hypoglycaemia results in a short period of convulsions progressing rapidly to death (Eales et al., 1982a).

The excellent practical work by Eales and co-workers (Eales et al., 1982a) led to the widespread adoption of the Moredun lamb thermometer in the assessment of comatose lambs and the use of glucose solutions by intraperitoneal injection to revive hypoglycaemic lambs. In the past decade the sheep industry has seen a dramatic increase in the number of flocks which are housed during the lambing period. As the ewes remain housed for the first one or two days after lambing the incidence of



hypoglycaemia in neonatal lambs has declined due to improved supervision and supplemental colostrum feeding of hungry lambs such that the technique of intraperitoneal glucose injection is now rarely practised.

### 3.6.5 THERMOGENESIS

Thermogenic mechanisms mature prenatally (Mellor, 1988) but show little evidence of increased heat production if the foetus is experimentally cooled in-utero (Gluckman, Gunn, Johnson and Fraser, 1985), partly because of the low foetal tissue oxygen tensions and partly through the action of a thermogenesis inhibitor thought to be produced in the placenta (Gluckman, Gunn, Johnson, Power and Ball, 1988). These physiological inhibitors are removed following birth of the lamb.

Lambs are born with glycogen and fat reserves in relation to the prepartum nutritional status of the dam (Alexander, 1964). Severe weather conditions can deplete these reserves in 6-16 hours but under normal environmental conditions lambs of adequate birthweight can survive without sucking for up to four days (Alexander, 1961). In unhygienic conditions this agammaglobulinaemic state, however, would render such lambs highly susceptible to bacteraemic or septicaemic conditions. The physical properties of colostrum are thought to be important in the initiation of intestinal motility (Scott, 1989) and the passage of meconium.

### 3.6.6 ACID-BASE BALANCE IN THE NEONATE

Respiration at birth represents a continuation of a process that begins early in intra-uterine life and matures during gestation (Breazile et al., 1988). Dystocia may result in severe acid-base imbalances caused by difficulties in breathing following premature rupture of the



umbilical vessels, protracted dystocia (Eales and Small, 1980b) and trauma during delivery (Szenci, Taverne and Takacs, 1989). Prolonged hypoxia is an important cause of foetal death during dystocia (Haughey, 1980) and if not fatal it can be an important factor determining survival (Dufty and Sloss, 1977).

Studies of bovine dystocia reveal that calves born after a difficult and delayed parturition had severe and prolonged lactic acidosis and lower plasma non-esterified fatty acid, T3 and T4 concentrations during the first few hours of life compared to normal calves (Vermorel, Vernet, Dardillat, Saïdo, Demigüe and Davicco, 1989). Such calves had a poor appetite and immunoglobulin absorption was delayed and reduced which, the authors suggest, is an important factor in the aetiology of high morbidity and mortality rates in calves born following dystocia (Vermorel et al., 1989). In addition these calves showed a reduction in rectal temperature during the first two hours after birth (Vermorel et al., 1989) which is in agreement with the results of studies in newborn lambs (Vermorel and Vernet, 1985). Reduced teat-searching and colostrum intake by calves showing hypoxia and hypothermia has been reported (Edwards, 1982).

In a study of hysterotomy-derived calves 63.5% had normal acid-base values, 23.8% slight acidosis and 12.7% had severe acidosis; six of 16 calves from the last group died within 48 hours of birth (Szenci, Taverne and Takacs, 1989). No reference could be found in the literature relating to studies of acid-base balance in lambs during the first few hours of life following varying degrees of dystocia.

### 3.6.7 EWE-LAMB BONDING

The establishment of the ewe-lamb bond during the first few hours after birth is critical for the survival of the lamb. This is especially so in the case of triplet lambs with low birthweights as such animals have the highest ratio of surface area to bodyweight and the highest rates of heat loss (Alexander, 1979).

The ewe's behaviour immediately following parturition is under a considerable amount of physiological control (Alexander, Poindron, Le Neindre, Stevens, Levy and Bradley, 1986; Krenbiel, Poindron, Levy and Prud'Homme, 1987). The normal prepartum decrease in maternal plasma progesterone concentration is delayed by underfeeding (Mellor, Flint, Vernon and Forsyth, 1987) and in lean sheep poorer mothering performance and impaired lactogenesis may both, in part, be due to this delayed withdrawal of progesterone (Mellor, 1988). This situation of poor mothering performance arises because progesterone may antagonise the actions of oestrogen which is necessary for maternal behaviour (Mellor, 1988).

Amniotic fluid odours are not attractive to sheep except at parturition and after an initial general acceptance of lamb odours, ewe receptiveness becomes specific within three to five hours of birth (Mellor, 1988). As well as reinforcing recognition, the vigorous licking of the lamb by the ewe also helps to dry the lamb's fleece and stimulates the lamb's respiration. Intensification of sheep farming and close confinement of ewes at lambing time means that ewe-lamb bonding is also subject to considerable management influences. Large group size and the limited extent to which a ewe can separate itself from other sheep often results in the ewe lambing in close proximity to other

sheep. In this situation no provision is made for normal behavioural patterns which are displayed by sheep during first stage labour in an extensive system. Frequent disruption by supervising farm staff and other sheep may unduly prolong second stage labour. In multiple births, the first lamb may wander away or be "stolen" by another ewe which has not yet lambed. It is generally recommended that, in order to ensure a strong ewe-lamb bond, a ewe should be penned with its lambs immediately following birth for up to one day.

### **3.7.1 MAMMARY GLAND FUNCTION**

Adequate dam nutrition during the last six weeks of pregnancy is essential to ensure normal mammary development, colostrum accumulation and subsequent lactogenesis (Barlow et al., 1987). During this period there is massive hyperplasia and differentiation of alveolar cells which secrete colostrum (Delouis, 1978). Maximum udder growth coincides with raised serum progesterone and lactogen concentrations which are both derived from the placenta (Mellor, 1987). The mammary gland is concerned with the secretion of lactose, protein and milk fat (Mepham, 1976a). Glucose is the base compound for lactose synthesis (Linzell, 1967) which itself determines milk yield (Mepham, 1976b) due to its osmotic properties (Swan, 1979).

Milk secretion follows the sucking of accumulated colostrum by the lamb (Mellor and Murray, 1985a, 1986) and reaches a peak one to three weeks after parturition (Clarkson and Faull, 1987).

### **3.7.2 TEMPORARY AGALACTIA AND VACCINATION**

McKellar (1985) reported an incident of temporary agalactia in Blackface sheep following vaccination with a combined clostridial and pasteurella

vaccine. It was postulated (McKellar, 1985) that injection of endotoxin from gram negative bacteria may have played a role in the agalactia but this could not be reproduced experimentally the following year.

### 3.7.3 MASTITIS

Lack of colostrum in individual ewes usually results from mastitis or debilitating disease such as ovine progressive pneumonia (Rook et al., 1990) and will severely prejudice lamb survival. It is unlikely that ewes with a debilitating disease such as Maedi (ovine progressive pneumonia) as outlined by Rook et al. (1990) would produce viable lambs, therefore lack of mammary gland function is perhaps of secondary importance.

During lactation experimentally induced subclinical mastitis in ewes has been shown to significantly reduce milk yield and lamb growth rate (Flhenakis and Jones, 1990) but such infections would not affect colostrum accumulation. Mastitis surveys at parturition have quoted mastitis-affected glands as between 4.5 to 7.0% for control sheep (Hendy and Pugh, 1981) and 0.5% for those ewes treated with an intramammary antibiotic infusion at the end of the previous lactation.

### 3.7.4 LEPTOSPIRA INTERROGANS SEROVAR HARDJO

Leptospira interrogans serovar hardjo has been implicated as an important cause of mastitis in ewes at lambing. McKeown and Ellis (1986) reported a 25% flock incidence of leptospirosis in 44 flocks investigated. No further reports on this subject have appeared in the literature and, therefore, it is difficult to assess the significance of leptospirosis in commercial flocks.

### 3.8.1. BODY CONDITION

Ewe body condition scoring (Jeffries, 1961) is a useful monitor of ewe nutritional status over the preceding weeks. Monitoring ewe body condition scores is most effective if performed regularly as an integral part of the annual management cycle. Ewe body condition scoring forms a valuable part of the assessment of ewe nutrition during pregnancy and target scores at varying stages have been recommended (Russel, 1985).

There are no experimental data to indicate a relationship between excessive ewe body condition during late pregnancy and an increased incidence of ovine pregnancy toxemia yet this opinion is widely held by veterinary surgeons. In their review, Forbes and Singleton (1964) quote numerous authors who reported pregnancy toxemia to result from overfatness and reduced exercise during pregnancy but these reports are not supported by experimental evidence. On the contrary, ewes in good body condition were better able to maintain plasma glucose concentrations than thin ewes following a fasting period (Reid and Hinks, 1963). Boundy (1985) reports that pregnancy toxemia in the overfat ewe can be difficult to treat but no results are provided to justify this statement. The most economic feeding system is likely to be below the calculated daily metabolisable energy requirement with this deficit matched by controlled weight loss over the winter period (Speedy and Greenwood, 1985).

High serum 3-OH butyrate concentrations were reported seven to ten days before clinical signs of ovine pregnancy toxemia occurred in ewes which were in very poor bodily condition (condition scores 1.0 to 1.5) (Scott, 1988). These ewes were reported to have been in good condition (condition score 3.0) one month earlier and the results in this instance

indicated that ovine pregnancy toxaemia resulted from a prolonged period of undernutrition with mobilisation of body reserves (Scott, 1988).

The biochemical changes that occur in ovine pregnancy toxaemia are not dissimilar to bovine ketosis where clinical disease is precipitated when the plasma glucose falls below a threshold concentration (Dale, Halse and Vik-Mo, 1978).

### **3.8.2 PERIPARTURIENT DISEASE INCIDENCE AND EXCESSIVE BODY CONDITION**

In dairy cows a marked increase in the incidence of periparturient diseases is reported for overconditioned dairy cows and in the United States the term "fat cow syndrome" has been attributed to this collection of clinical conditions (Morrow, Hillman, Dade and Kitchen, 1979). Examination at necropsy reveals marked fatty infiltration of the parenchymatous organs.

Various postulates have been suggested to explain the relationship between fatty degeneration and disease incidence in the periparturient period. As vitamin D<sub>3</sub> is hydroxylated to its active form in the liver (Russell, 1979), Reid (1980) suggests that impairment of this pathway in the liver by fatty infiltration of hepatocytes increases the incidence of bovine hypocalcaemia.

There are no reports in the literature which indicate an increased incidence of periparturient disease in sheep in association with high body condition scores although the opinion is widely held that fat ewes are more prone to ovine pregnancy toxaemia (Boundy, 1985).

### 3.8.3 FATTY LIVER DISEASE

While a significant positive correlation is observed for lactating cows between hepatocyte fat content and circulating free fatty acids concentration (Roberts, Reid, Rowlands and Patterson, 1981), no significant correlation exists between subcutaneous fat depot depth and the rate of lipolysis determined by circulating free fatty acid concentration (Pike and Roberts, 1980). This may suggest that factors other than or in addition to fatness are responsible for the development of fatty liver. As the rate of lipolysis is as high two weeks prepartum as two weeks postpartum, West (1988) postulates that fat mobilisation is a normal physiological adaptive process.

A body condition of 3.0 to 3.5 is considered optimum for ewes entering late gestation as some catabolism of body tissue will result from the negative energy status that occurs as pregnancy advances and foetal demands increase. In addition, catabolism of fat and protein body reserves will continue into lactation resulting in increased milk production and improved liveweight gains of lambs, particularly during the first month of life. The poor lamb liveweight gains reported by Harding et al. (1984), for example, could be the result of poor ewe condition at lambing although many other management influences can be involved, not least ewe nutrition and grazing management.

There are no reports in the literature that indicate a positive correlation between the degree of fatty infiltration of parenchymal organs and the incidence of periparturient disease in sheep. Unlike dairy cattle the incidence of hypocalcaemia and mastitis in sheep is very low in the periparturient period and metritis is primarily related to unhygienic or excessive interference of a dystocia. It is possible



that an increased amount of adipose tissue in the vaginal wall may result in an increased incidence of post dystocia vaginal tears and associated oedema but this incidence is purely the result of negligent management and not a primary effect.

### **3.9.1 NORMAL PARTURITION**

The normal gestation length in the ewe is 147 days. Imminent parturition is signalled by isolation from the remainder of the flock, temporary inappetance, udder development with the presence of colostrum and slackening of the sacro-iliac ligaments. First stage labour ends with complete dilation of the cervix. Second stage labour starts with rupture of the allanto-chorion followed by the amnion and eventual expulsion of the foetus. Third stage labour usually ends two to three hours later with expulsion of the foetal membranes.

### **3.9.2 SYNCHRONISATION OF PARTURITION**

While induction of parturition as an aid in the management of bovine dystocia has been reported (Bailey, McLennan, McLean, Handford and Munro, 1973; Baker, Copland, Rival and Thorpe, 1988), the beneficial treatment results obtained arise from closer supervision and more timely intervention in dystocia cases.

The use of preparations to synchronise the timing of parturition in a group of ewes has been reported in experimental situations. Epostane has been successfully used to induce parturition after day 136 of gestation (Silver, 1987). Delay of second stage labour by up to ten hours has been reported following the administration of clenbuterol (Plant and Bowler, 1988). It is unlikely that either of these preparations would have any commercial, large scale use.



In a study involving 896 ewes on commercial farms (Trower, 1991), the synchronisation of mating, following the removal of progestogen sponges, permitted induction of parturition of all ewes on a single day (day 141 of gestation) using 10-12mg betamethasone. Ninety-five percent of ewes lambed within 70 hours of injection, however, despite the concentration of management resources during this period the perinatal mortality rate was not reduced. It is unlikely that with natural service the gestation length could be determined accurately and thereby the date for induction of parturition could only be approximated. It was concluded (Trower, 1991) that the technique of induction could not be justified on financial or ethical grounds.

### 3.10.1 DYSTOCIA

Reporting on an extensive survey in New Zealand of 23,000 lambs, Gumbrell (1985) suggested that dystocia was the main cause of death with 74% of all lambs showing evidence of trauma. It was concluded that dystocia may be insufficient in itself to cause death but could result in a reduced ability to suck and/or seek shelter thereby increasing lamb losses from the starvation, mismothering, exposure complex. In the survey of dystocia in the United Kingdom (Ellis, 1958) few of the categories of malpresentation, malposition and malposture should result in trauma to the lamb. In the field situation if the lamb cannot be delivered easily then a caesarian operation is indicated. The 74% incidence of trauma observed in lambs at necropsy (Gumbrell, 1985) suggests excessive use of force or lack of expertise of the operator. If trauma has occurred to the lamb during delivery then it is certain that there will be soft tissue trauma to the posterior reproductive tract of the ewe. If the lamb trauma was caused by incompetent interference of a dystocia then it could be argued that the operator's attention to

hygiene at delivery would be similarly questionable. Both excessive and unhygienic interference of a dystocia would result in vaginitis, cervicitis, extending to metritis. Therefore, lambs presented at necropsy with evidence of starvation may equally be the result of agalacia caused by infection of the posterior reproductive tract and associated toxæmia of the ewe. Again, it is unlikely that such an illness would be recognised in the early stages except by a diligent stockman. The significance of traumatic lesions in the lamb at necropsy in itself is incomplete as the cause of starvation could equally be caused by agalactia of the dam. A clinical assessment of the dam is essential before firm conclusions can be reached regarding starvation of the lamb.

Dystocia was an uncommon cause of perinatal lamb mortality in a flock with continuous supervision with only 0.45% of lambs dying as a direct result of dystocia (Safir, 1991). While an assisted dystocia can result in rupture of the liver (Johnston and MacLachlan, 1986) or damage to the rib cage if excessive force has been used, attention has focused on the significance of central nervous system lesions in delayed delivery and dystocia cases.

### **3.11.1 CENTRAL NERVOUS SYSTEM LESIONS**

The common central nervous system lesions observed in 56-86% of perinatal lamb losses in the flocks studied by Haughey (1985) were subdural, subarachnoid and extradural haemorrhages. These haemorrhages were interpreted as a sensitive index of damage to basic "neural elements" of the foetal central nervous system. Based on necropsy findings which demonstrated that 21% of lambs with meningeal haemorrhage died compared to an incidence of only 1.4% in the control lamb group,

Haughey (1985) postulated that severe dystocia would result in intrapartum death, less severe dystocia would cause damage to the central nervous system leading to impaired feeding, locomotor and metabolic activity which collectively would contribute to the starvation, mismothering, exposure complex.

In the flock investigated by Wilsmore (1986) 50% of ewes experienced a dystocia with a subsequent perinatal lamb mortality rate of 17%. Of these deaths 55% were attributed to birth injuries and anoxia. When second stage labour is prolonged gradual or intermittent foetal anoxia produces specific vascular changes resulting in weakening of the capillary walls manifest at necropsy as haemorrhages particularly apparent in the thymus, pleura, epicardium and in the central nervous system (Wilsmore, 1989).

In a study of ewes with an average litter size of 2.26 and a perinatal lamb mortality rate of 29% only 1% of deaths was attributed to dystocia compared to a stillborn rate of 44% (Khalaf et al., 1979b). These data suggest that in a prolific flock with multiple births, birth injury is a relatively unimportant factor influencing the perinatal lamb mortality rate. In other field studies of perinatal lamb mortality, workers have not considered examination of the central nervous system as an important part of their necropsy examination (Safir, 1991).

Furthermore, in the case of singletons, a high plane of nutrition during late pregnancy increased the lamb birthweight by only 0.4kg (5.9 vs. 5.5kg) compared to ewes on a low nutritional plane (Khalaf et al., 1979a). Such a relatively small increase in birthweight is unlikely to

result in a significant rise in the dystocia rate due to absolute foetal oversize.

### **3.11.2 LOCALISATION OF CENTRAL NERVOUS SYSTEM LESIONS**

Unfortunately, in the study by Haughey (1985) no data were provided on the distribution of the central nervous system haemorrhages. Localised lesions would be expected to show signs of a specific neurological syndrome (Braund, 1985). These data would be invaluable in attempting to relate central nervous system function to location of the haemorrhage within the central nervous system. A practical guide to neurological examination of sheep and localisation of a lesion has been described (Skerritt, 1984).

Cerebellar hypoplasia and cerebellar hypomyelogenesis can occur respectively in cases of congenital Border Disease virus infection (Nettleton, 1988) and in congenital swayback (Barlow, 1983) but these animals are capable of independent existence after appropriate nursing initially. The clinical significance of the space occupying nature of some central nervous system haemorrhages could therefore be questioned.

### **3.11.3 CEREBRAL OEDEMA**

Increased pressure within the cranial cavity due to the development of cerebral oedema and increased cerebrospinal fluid pressure is reported in such conditions as polioencephalomalacia (Scarratt, 1981) and meningitis. In both conditions considerable damage to the central nervous system can occur before death ensues. In untreated cases the clinical course of these conditions is often between three to five days.

#### **3.11.4 SIGNIFICANCE OF CENTRAL NERVOUS SYSTEM HAEMORRHAGE**

It is probable that central nervous system haemorrhage is only an indicator of dystocia and that death was the result of severe physiological disruption, for example profound hypoxaemia or acid-base disturbance. Meningeal haemorrhages were not observed in any of the dead lambs in the flock investigated by Barlow et al. (1987) where the perinatal lamb mortality rate was 17%.

#### **3.12.1 PERINATAL MORTALITY IN CALVES**

Field observations have demonstrated a positive correlation between the mortality rate of calves and degree of dystocia (Gee, Garden and Harper, 1989). Unfortunately no mention is made in that study of the need for surgical correction of the dystocias and the high mortality rate in that study may, in part, be related to prolonged first and second stage labour and placental dehiscence.

The high mortality rate in heifers' calves is almost invariably related to the choice of sire breed. Gross pathology of calves which died during parturition was unremarkable with only relatively mild oedema of the head (Gee et al., 1989) which may suggest physiological causes of intrapartum death.

Studies on heifers demonstrated that dystocia significantly delayed the interval from calving to the calf standing and was associated with significantly reduced calf serum immunoglobulin concentrations (Odde, 1988).

### **3.12.2 CENTRAL NERVOUS SYSTEM LESIONS IN BOVINE DYSTOCIA**

In a recent review of bovine neurological diseases (Baker, 1987) no reference is made to an association between central nervous system haemorrhage and maladjustment syndromes in bovine neonates or to an increased calf mortality rate. The high incidence and severity of some bovine parturitions, particularly in heifers, might be expected to result in a high incidence of central nervous system haemorrhage as the calf's head may be subject to considerable external forces while in the pelvic canal. However, cases of bovine dystocia more commonly result in trauma to the peripheral nerves (Ciszewski and Ames, 1987) rather than central nervous system involvement. Even then the reported incidence of peripheral nerve damage is low (Ciszewski and Ames, 1987).

No explanation for the low incidence of central nervous system haemorrhages following dystocia in the bovine could be found in the literature. The low incidence of central nervous system haemorrhages is surprising when the traction forces used are considered and the fact that other physical injuries to the calf such as limb fractures, fractures of the ribs and/or costal arch are reported to occur commonly at an "assisted" dystocia.

### **3.13.1 CENTRAL NERVOUS SYSTEM LESIONS IN FOALS**

The importance of neonatal central nervous system function and possible significance of central nervous system haemorrhages has been studied in greatest detail in the equine neonate.

The neonatal maladjustment syndrome of foals is a common problem of equines and has recently been reviewed (Mayhew, 1989). Intercurrent bacterial infection, particularly respiratory disease and meningitis,

can make a specific diagnosis of neonatal maladjustment syndrome difficult (Clement, 1985). Indicators of prematurity which include hyper-extension of fetlocks and thin, supple skin can be associated with this syndrome (Leadon, Jeffcott and Rosedale, 1986; Vaala, 1986).

### 3.13.2 NEONATAL MALADJUSTMENT SYNDROME

Initially, Rosedale (1969) defined neonatal maladjustment syndrome as those full-term foals which showed signs of cerebral dysfunction. Now there is a wide range of neurological signs attributed to neonatal maladjustment syndrome which includes dementia, circling, blindness, loss of suck reflex, seizures, specific cranial nerve deficits, tetraparesis and hyporeflexia (Mayhew, 1989).

Age at onset of neurological signs has an effect on prognosis as those foals which had an abnormal parturition and showed neurological signs almost immediately had a higher mortality rate than those which were normal at birth and soon ambulatory (Clement, 1987). However, the abnormal behaviour observed immediately after birth, frequently associated with assisted parturition, may also indicate systemic illness acquired in-utero as well as lesions resulting from the dystocia. Necropsy of such foals reveals multiple organ damage caused by a severe hypoxic episode or a septic process (Clement, 1987).

The aetiology of neonatal maladjustment syndrome is incompletely understood but is considered to be the result of parenchymal and subarachnoid haemorrhages, neuronal necrosis, oedema and malacia in the spinal cord and brain (Haughey and Jones, 1976; Palmer and Rosedale, 1976; Mayhew, 1982; Palmer, Leadon, Rosedale and Jeffcott, 1984).

Numerous studies have, however, highlighted the poor correlation between



the distribution and extent of these lesions and the clinical manifestations (Mayhew, 1982; Palmer et al., 1984; Clement, 1987).

Seizure activity in lambs has not been reported as a result of ovine dystocia and central nervous system haemorrhages but is a common finding in neonatal maladjustment syndrome in foals. Numerous causes for the convulsive and allied syndromes of the neonatal foal have been postulated including central nervous system trauma resulting from dystocia (Haughey and Jones, 1976), cardiovascular (Johnson and Rosedale, 1975; Rosedale, Jeffcott and Palmer, 1976) and respiratory dysfunctions (Palmer and Rosedale, 1976; Mayhew, 1982). Haemorrhage and oedema of the central nervous system may occur at parturition and progress resulting in seizures later (Clement, 1987). Metabolic changes due to impaired pulmonary or cardiovascular function may result in hypoglycaemia, acid/base and electrolyte disturbances which exceed the seizure threshold and cause convulsions.

The neurological signs of the convulsive foal are divided into four phases: pre-ictal, ictal, comatose or semicomatose and recovery (Mahaffey and Rosedale, 1957).

The pre-ictal phase is characterised by abnormal behaviour including wandering, blindness and altered mental state.

The ictal or seizure phase appears suddenly with jerky movements of the head, neck and limb muscles, hyperaesthesia, vocalisation and odontopresis. This may be followed by opisthotonus, extensor rigidity and abnormal vocalisation. Seizures can last for a





prolonged period if untreated and some foals may die.

This period may be followed by a quiet phase in which the foal has altered consciousness, shows abnormal responses and can be comatose. This period can be prolonged, lasting several days.

The last phase is one of slow recovery over days to weeks. Ability to remain standing and then to rise unaided are good prognostic indicators.

### **3.13.3. TREATMENT OF NEONATAL MALADJUSTMENT SYNDROME**

Generalised seizures must be controlled immediately unless serious damage to the central nervous system results. Diazepam and phenobarbital are the anticonvulsant drugs of choice. The use of corticosteroids to reduce cerebral oedema is controversial because they are immunosuppressive and can adversely affect adrenal gland function (Clement, 1987). The application of dimethyl sulfoxide for the treatment of central nervous system trauma, thrombosis and oedema has been reviewed (Brayton, 1986). However, dimethyl sulfoxide does not have a product licence for animal use and care is necessary when handling this substance. The use of dimethyl sulfoxide is likely to be limited to expensive animals in hospital-standard facilities.

### **3.13.4 PATHOLOGICAL CHANGES FOLLOWING CENTRAL NERVOUS SYSTEM TRAUMA**

Neurological damage to the central nervous system is due to the immediate and direct disruption of neural tissue and vasculature and to delayed indirect mechanisms (Stewart, 1987). The immediate injury is characterised by haemorrhage which can extend to considerable

haemorrhage with necrosis and oedema (Griffiths, 1987). This haemorrhage damages pathways causing functional disturbances remote from the site of vascular damage. The delayed damage has been associated with a decline in cerebral and spinal cord blood flow (Wallace and Tator, 1986).

Three clinical syndromes have been recognised in cranial trauma in the horse: cerebral, midbrain and medullary inner ear (Mayhew and McKay, 1982). The prognosis for cerebral injury is good but poor for the midbrain syndrome. Treatment includes the establishment and maintenance of a patent airway, administration of fluids and drug therapy designed to prevent or reduce cerebral oedema (Hayes, 1987; Reed, 1987).

#### **3.13.5. CEREBROSPINAL FLUID CHANGES IN NEONATAL MALADJUSTMENT SYNDROME**

Diagnosis of neonatal maladjustment syndrome is often complicated by the presence of intercurrent infectious disease. Cerebrospinal fluid analysis sometimes reveals mild haemorrhage with xanthochromia (Mayhew, 1989) but data are not presented.

#### **3.13.6 PATHO-PHYSIOLOGICAL CHANGES DURING PARTURITION**

During an equine dystocia rapid fluctuations in acid-base balance, blood gas composition and blood pressure of the foal probably result in hypoxic and ischaemic damage to the foal's central nervous system blood vessels and parenchymatous organs. Once again, however, there is a poor correlation (Mayhew, 1988) between the presence and severity of central nervous system dysfunction and the presence of unequivocal hypoxic-ischaemic brain damage in individual foals dying after demonstrating signs of neonatal maladjustment syndrome.

### 3.14.1 LAMB BIRTHWEIGHT

The relationship between low lamb birthweight and increased perinatal mortality has been reported by many workers including Khalaf et al. (1979b) and Struber et al. (1979a). This may not always be a linear relationship, for example, high birthweight singleton lambs may experience a higher dystocia rate which, if incorrectly supervised, may result in increased lamb mortality of this group of lambs. Low birthweight triplet lambs may also experience a relatively higher mortality rate if adequate care and attention to colostrum administration are not practised.

On a within-group analysis a highly significant ( $P < 0.01$ ) lower birthweight was reported for twin and triplet lambs which died during the perinatal period compared to those lambs which survived (Barlow et al., 1987).

Unless the service date of the ewe is known accurately it may not be possible to ascribe low lamb birthweight to placental function, poor dam nutrition, premature birth or a combination of these factors.

### 3.14.2 DAM NUTRITION AND LAMB BIRTHWEIGHT

Viable lamb birthweights are dependent upon adequate dam nutrition during two critical phases of development: firstly, the development of the placenta between days 30-90 (Alexander and Williams, 1971) and secondly, the period of maximum foetal growth during the last six weeks of gestation (Russel, Maxwell, Sibbald and McDonald, 1977). If ewes are subjected to prolonged undernutrition these negative influences on foetal growth are additive and result in the birth of small lambs (Mellor and Murray, 1982a; Mellor, 1983).

Severe underfeeding of single and twin-bearing ewes during late pregnancy results in a 20-25% reduction (1-1.2kg) in lamb birthweight (Russel et al., 1977; Mellor and Murray, 1982). These data are similar to the results of Robinson, Brown and Lucas (1973), Shevah, Black and Land (1975) and Valdez Espinosa, Robinson and Scott (1977) where reductions in energy intake have a progressive negative influence on lamb birthweight.

The method employed by Russel et al. (1977) was to weekly adjust individual feed intakes of housed, mature Greyface ewes to maintain plasma 3-OH butyrate concentrations during the final six weeks of pregnancy at the following values:

treatment 1 (adequately nourished) less than 0.7mmol/l;

treatment 2 (moderately undernourished) at about 1.1mmol/l;

treatment 3 (severely undernourished) at about 1.6mmol/l.

The mean daily metabolisable energy (ME) intakes of twin-bearing ewes were 16.3, 11.6 and 10.0 MJ(ME)/day (Russel et al., 1977). While there was a relatively small difference in daily metabolisable energy allowances between the ewes in groups 2 and 3 of only 1.6 MJ/day, the mean lamb birthweight was 0.8kg heavier for the progeny of group 2. This difference in lamb birthweight may suggest that there is an important metabolic step represented by 3-OH butyrate concentrations of 1.1 and 1.6mmol/l which has been arbitrarily referred to as the difference between moderate and severe undernutrition. This work is based on previous work with Scottish Blackface ewes (Russel, Doney and Reid, 1967a, 1967b).

The interaction between lamb birthweight, nutritional management of the dam and litter size is well illustrated in the results presented by Khalaf et al. (1979a). These data reveal zero mortality for well-fed ewes with singletons or twins but a mortality rate of 41.7% for triplets from ewes on a low nutritional plane. A birthweight reduction of 1.2kg to a mean 3.5kg in the case of severely underfed twin-bearing ewes (Khalaf et al., 1979a) is likely to prejudice survival in the neonatal period. Analysis of the data presented by Barlow et al. (1987) showed that the lamb mortality rate increased with litter size (singles 10%, twins 12% and triplets 26%) (Barlow et al., 1987). Surprisingly, in the work reported by Barlow et al. (1987) the lamb deaths did not correlate significantly with the ewes' condition scores.

In the study by Barlow et al. (1987) the general nutritional status of the ewes was judged to be adequate in that their plasma copper and vitamin B<sub>12</sub> concentrations were satisfactory and less than 10% of the ewes were severely undernourished, as judged by a condition score of 1.0. Interestingly, the plasma copper concentrations were significantly lower in the ewes with single lambs where nutritional status would be expected to be higher. A single body condition score is of little value and more useful information would have been provided if condition scores had also been recorded six weeks prior to lambing.

### **3.14.3. PLACENTAL DEVELOPMENT AND DAM UNDERFEEDING**

If normal placental development has taken place, a period of dam underfeeding during the last six weeks of pregnancy does not result in foetal hypoxia (Boyd, Morris, Meschia, Makowski and Battaglia, 1973) and foetal loss is uncommon (Mellor and Murray, 1981, 1982b). Increased perinatal mortality would result only if the level of ewe undernutrition

reduced colostrum accumulations below lamb requirements. A shortfall in colostrum yield occurs with large litters (Mellor and Murray, 1985a) and supplementary feeding of the lambs is necessary.

#### 3.14.4 DAM NUTRITION AND PERINATAL MORTALITY

A highly significant relationship was observed between low lamb serum immunoglobulin concentrations and perinatal mortality in triplet lambs (Khalaf et al., 1979b). In that study 25% of all lamb deaths were attributed to lack of colostrum/milk and the infections contributing to mortality were nearly all associated with E. coli. The consistent isolation of E. coli would indicate high levels of environmental challenge. As well as the lack of passively-acquired immunoglobulins, the lambs' depleted reserves of liver glycogen and fat deposits, as a consequence of dam undernutrition, would reduce the duration for which effective thermogenesis could be maintained (Mellor and Murray, 1985b; Mellor and Cockburn, 1986). Hypothermia could, therefore, be a contributing factor in the death of these triplet lambs.

Underfeeding of the dam during late gestation may also increase lamb perinatal losses as undernourished ewes exhibit poorer mothering instincts and may abandon one or more of their lambs (Alexander, 1960). Intercurrent infections, particularly parasitic gastroenteritis (PGE), compound undernutrition during late gestation (Donoghue and Kronfeld, 1990). Water intake is critical for optimum production and reduced water intake can lead directly to rumen impaction, decreased milk yield or indirectly result in ovine pregnancy toxemia (Donoghue and Kronfeld, 1990).

### 3.15.1 PREMATURE BIRTH

Abortions, stillbirths and the deaths of apparently premature lambs were major factors in an overall lamb mortality rate of 29% (Khalaf et al., 1979a), although there are no criteria quoted which would differentiate between an aborted lamb and a premature lamb. Unless gestation length is accurately determined the degree of prematurity is difficult to assess.

### 3.15.2 MATERNAL STRESS

The statement that maternal stress can result in premature birth because of transplacental transfer of cortisol (Mellor, 1988) is unsupported by experimental data and contrary to field observations. For example, metabolic disease such as ovine pregnancy toxemia, caused by severe prolonged underfeeding, may cause death of the ewe yet foetal loss does not occur (Ford, 1983). In the author's experience the treatment of a ewe suffering from ovine pregnancy toxemia with high doses of parenteral corticosteroids (16mg dexamethasone) does not result in abortion unless the ewe is within ten days of her expected lambing date. Maternal stress would, therefore, appear to be an uncommon cause of foetal loss during late gestation.

A marked rise in foetal plasma cortisol concentration is the trigger which is central to the co-ordination of:

1. initiation of labour and the completion of the birth process;
2. maturation of foetal organs;
3. stimulation of prenatal colostrum accumulation;
4. induction of maternal receptivity and mothering ability

(Mellor, 1988).



### 3.15.3 PLACENTAL INSUFFICIENCY

Premature birth is a common sequel to placental insufficiency (Mellor, Mitchell and Matheson, 1977) which results from premature increases in foetal plasma cortisol concentration (Robinson, Jones and Kingston, 1983) in response to reduced foetal oxygen and/or nutrient supply. Such placental insufficiency may explain the birth of triplet lambs two to three days before twin lambs where the sheep were mated on the same day.

A physiological assessment of the cause of death in neonatal lambs has been reported (Barlow et al., 1987) based on altered plasma composition, birthweight, rectal temperature and age at death with five categories defined: placental insufficiency, acute intrapartum hypoxaemia, inadequate thermogenesis, starvation and no diagnosis. The cause of lamb deaths was assigned to one of the first four categories when specific combinations of variables differed by one or more standard deviations from the means of the surviving lambs.

Based on this classification, singles, twins and triplets were fairly evenly distributed among the first four categories and both the frequency and cause of death were independent of the birth order in twins and triplets (Barlow et al., 1987). These results may be contrary to expectation, for example, few single lambs would be expected to show evidence of placental insufficiency. Similarly, inadequate thermogenesis would be unlikely due to the presence of sufficient brown fat reserves in single lambs of adequate birthweight. Placental insufficiency would be expected in triplets due to lower placental weight and the reduced number of caruncle attachment points per lamb.



#### **3.15.4 MATERNAL UNDERNUTRITION**

Premature birth is reported to be caused by severe maternal underfeeding during late pregnancy (Mellor and Matheson, 1979; Mellor and Murray, 1982a). In the field situation the influence of such underfeeding is difficult to quantify as many factors can result in the birth of small, weakly lambs. In addition, gestation length can only be approximated in most flocks as the raddles are only changed weekly.

Severe maternal underfeeding resulting in ovine pregnancy toxæmia does not usually result in the birth of premature lambs (Wierda, Verhoeff, Vandijk, Dorresteyn and Wensing, 1985; Buswell, Hardy and Bywater, 1986) and frequently death of the ewe occurs before any signs of impending abortion. It is possible that the two to four week period of undernutrition during late gestation, which precipitates some cases of ovine pregnancy toxæmia, may also cause reduced foetal adrenal cortex function. Consequently the low foetal plasma cortisol concentrations may be insufficient to initiate the normal birth process.

#### **3.16.1 PATHO-PHYSIOLOGICAL CAUSES OF NEONATAL MORTALITY**

Post mortem examination of neonatal lamb deaths often fails to take into account the fact that prenatal and intrapartum disturbances can seriously prejudice the survival of new born lambs (Mellor, 1988). Barlow et al. (1987) clinically examined and collected blood samples from 818 lambs born alive in a flock which had a neonatal mortality rate of 18%. Variables measured within 15 minutes of birth included birthweight, rectal temperature, haematocrit, plasma fructose and lactose concentrations. These criteria identified lambs as suffering from placental insufficiency, acute intrapartum hypoxaemia, inadequate thermogenesis and starvation. According to this physiological

assessment, 71%, 13% and 16% of the deaths were attributed to prenatal, postnatal and undiagnosed respectively. Clinicopathological evaluation gave figures of 26%, 59% and 15%. It is evident that the use of clinicopathological criteria alone markedly underestimates the impact of prenatal physiological impairment on postnatal survival (Mellor, 1988). However, such opinions are not universally accepted especially as the flock studied by Barlow et al. (1987) was adjudged to have been well fed.

### **3.17.1 POST MORTEM EXAMINATION OF PERINATAL LOSSES**

The importance of post mortem examination of lambs as a guide to veterinary advisory input has been emphasised by Hindson and Winter (1990). The approach to necropsy of newborn lambs has been expertly described by Rook et al. (1990). This work concentrates on the field investigation of lamb mortality and provides invaluable information, particularly on the interpretation of the degree of fat mobilisation in the neonate. The recommendation is that a large number of gross necropsies should be performed (Rook et al., 1990), rather than a smaller number of very detailed necropsies. This approach is more likely to provide the clinician with a more representative assessment of the flock situation. It is interesting to note that in contrast to other studies (Haughey, 1985; Wilsmore, 1986) examination for central nervous system haemorrhage is not mentioned in the necropsy technique of Rook et al. (1990).

In dystocia cases straw-coloured transudates in the pleural and pericardial cavities are thought to result from increased permeability of the capillaries of anoxic lambs (Wilsmore, 1986) due to prolonged second stage labour. Congestion and oedema around the larynx and

trachea is considered to be caused directly by birth injury (Wilsmore, 1986.)

### 3.18.1 WATERY MOUTH

Prior to sucking, the abomasum of newborn lambs is distended with clear mucus (Rook et al., 1990) and the ingestion of adequate colostrum is important for the initiation of gut motility. Delayed development of abomasal and intestinal mechanical function may be important in the aetiology of watery mouth. The clinical signs associated with watery mouth include excess salivation, lethargy, inappetance, abdominal distension and gut stasis (Mitchell and Linklater, 1983; Collins, Eales and Small, 1985). Lambs born into a contaminated environment and with a low intake of colostrum are most at risk (Hodgson, King, Moon, Hay and Quirie, 1988). Delayed passage of meconium is thought to be an important predisposing factor in the aetiology of watery mouth (Nixon, 1991). The incidence reached 20% of lambs born into a new sheep building due to the build up of infection during that lambing period (Eales, 1985). The incidence of watery mouth in one flock study (Eales, 1985) was singles 14%, twins 21% and triplets 32% but there was no significant difference in lamb birthweights between affected and healthy lambs. A high incidence in triplet lambs has also been reported (Nixon, 1991). The association between watery mouth in lambs from lean ewes (condition score less than 3.0) suggests the amount of accumulated colostrum could be an important factor.

The routine administration of metoclopramide, which acts to increase and co-ordinate intestinal motility, reduced the incidence of watery mouth in a field study (Scott, 1988). In watery mouth the experimental findings of increased concentrations of plasma lactate and urea and

decreased glucose and leucocytes (Hodgson et al., 1988) are consistent with the biochemical features of induced endotoxaemic shock (van Miert, van Dvin, Verheijden and Schotman, 1983; Naylor and Kronfeld, 1986). It is now generally accepted that endotoxaemia is an important factor in the development of watery mouth disease (Hodgson et al., 1988).

### **3.19.1 PROPHYLACTIC ANTIBIOTICS IN THE CONTROL OF PERINATAL DISEASES**

In the USA the routine use of long-acting antibiotic preparations to lambs on days 1 and 3 after birth in flocks with mounting pneumonia losses whose owners are unwilling to correct management problems has been recommended (Rook et al., 1990).

Control measures for watery mouth have been outlined (Eales, 1985) including the use of oral antibiotics within the first 15 minutes of birth. Oral antibiotics are now routinely used on the majority of farms in the United Kingdom to control watery mouth (Hodgson et al., 1988). Despite the report (Wells, 1984) of a reduced incidence of watery mouth following dam vaccination with an E. coli vaccine containing the K99 and F41 adhesins, such vaccination has largely proved unsuccessful in the control of watery mouth. No support could be found in the literature for the report of 20-43% incidence of enterotoxigenic E. coli (ETEC) (Snodgrass and Angus, 1984) in scouring lambs in the United Kingdom and United States of America.

### **3.20.1 MANAGEMENT FACTORS AND PERINATAL DISEASE**

As a general rule one lambing pen for every three to five ewes is sufficient (Rook et al., 1990). For lowground ewes a 1.5m x 1.5m pen is recommended. While cleaning and disinfection of lambing pens between ewes is strongly recommended there are no published data reporting

disease prevalence rates in situations where cleaning and disinfection are practised compared to continual pen usage. However, the cleanliness of the sheep shed itself is also of critical importance as contamination of the ewe's fleece and the lambs' umbilical vessels can occur prior to penning-up.

As outlined above, many farmers routinely administer oral antibiotics to lambs within the first 15 minutes of birth to control enteric infections. The extent to which such routine antibiotic prophylaxis also controls joint ill, meningitis and other localised infections which develop from a previous bacteraemia has not been determined.

#### **3.21.1 ASSESSMENT OF EWE NUTRITION DURING GESTATION**

A number of methods of monitoring ewe nutrition during gestation, particularly during the last six weeks, have been described and are reviewed below.

#### **3.21.2 CONDITION SCORING**

Condition scoring throughout gestation is an excellent management tool for the continuing assessment of the nutritional status of the pregnant ewe (Rook et al. 1990). It is generally recommended that ewes should be in a condition score of 3.0-3.5 at mating and 2.0-2.5 at lambing (Russel, 1985).

Donoghue and Kronfeld (1990) report that a diagnosis of energy deficiency can be made from a history of low ewe body condition scores and the presence of ketones in urine or milk. This recommendation fails to take into account the influence of mid-pregnancy nutrition on

ewe body condition score and, as the authors state, this is of historical value only.

### **3.21.3 DETERMINATION OF EWE LIVEWEIGHT CHANGE**

Ewe liveweight change during late gestation is considerably influenced by the weight of uterine contents. However, in experiments where the energy status of ewes was maintained during the last six weeks of pregnancy by weekly monitoring of plasma 3-OH butyrate concentration, adequate nutrition resulted in a significant increase in ewe liveweight of approximately 10kg compared to changes of only 5kg for moderately underfed and 3kg for severely underfed ewes (Russel et al., 1977).

### **3.21.4 MONITORING LAMB BIRTHWEIGHTS**

Rook et al. (1990) recommended that the first ten lambs born each year should be weighed and if these weights are not reasonable the amount of concentrate offered to the remaining pregnant ewes should be increased. This recommendation is unlikely to significantly increase lamb birthweights due to the compact lambing period whereby 80% of ewes lamb within the first ten days of the lambing period.

### **3.21.5 OCCURRENCE OF OVINE PREGNANCY TOXAEMIA CASES**

The occurrence of clinical cases of ovine pregnancy toxaemia is an extreme and unreliable method by which to assess ewe nutritional status (Scott, 1988). This is because litter size and hence energy requirements within a flock are variable and individual ewe factors such as age, dentition, lameness, vaginal prolapse and intercurrent infections may result in reduced appetite and energy intake which may precipitate ovine pregnancy toxaemia. Such individual factors may not justify the extrapolation of severe underfeeding of the remainder of the

flock. Considerable variation in individual feed intake at feeding times has also been reported (Kendall, Ducker and Hemingway, 1983).

Pregnancy toxaemia affected 0.5% of ewes in a Canadian survey (Dohoo, Curtis and Finley, 1985) and was identified on 16% of Pennsylvania farms studied (Donoghue et al., 1980). These data, however, are an unreliable guide to the prevalence of underfeeding in those flocks. Ovine pregnancy toxaemia is stated to be surprisingly common in housed sheep (Linklater, 1986b) usually due to inadequate trough space although no data are provided.

### **3.21.6 METABOLIC DISEASE IN PREGNANT SHEEP RESEMBLING**

#### **OVINE PREGNANCY TOXAEMIA**

The term downer ewe syndrome has been used (Logue, Brodie and Bogan, 1990) to describe illness characterised by depression, lethargy and in some cases recumbency and death in heavily pregnant sheep one to five days after vaccination against the clostridial diseases and treatment with an anthelmintic plus flukicide (levamisole and oxclosamide).

Clinical signs resembled ovine pregnancy toxaemia and in some cases 3-OH butyrate concentrations were elevated. Symptomatic treatment was largely ineffective. At necropsy in all cases the ewes were twin-bearing and showed signs of centrilobular fatty change of the liver typical of ovine pregnancy toxaemia.

While the cause of this syndrome could not be ascertained it was concluded that its basis was liver dysfunction leading to ovine pregnancy toxaemia (Logue et al., 1990). These authors concluded that controlled studies of liver function in ewes carrying multiples during late pregnancy are overdue.



### **3.21.7 THEORETICAL CALCULATION OF ENERGY SUPPLY**

Accurate estimates of energy supply from pasture are difficult to obtain and the usual procedure is to determine intakes of concentrates, hay and silage (Donoghue and Kronfeld, 1990). These data are often too inaccurate for meaningful analysis as the concentrate allowance rarely contributes more than 50% of the ewe's daily metabolisable energy requirement. A model of minimum feed requirements during pregnancy necessary to ensure satisfactory lamb production and acceptable changes in ewe body condition has been described (Speedy and Greenwood, 1985).

### **3.21.8 METABOLIC PROFILE TESTING OF PREGNANT EWES**

Metabolic profile testing in combination with theoretical ration formulation data has proved to be a very useful guide for dairy cattle ration modification (Kelly and Whitaker, 1982; Kronfeld, Donoghue, Copp, Stearns and Engle, 1982). The usefulness of metabolic profile testing in clinical practice for sheep flocks has been questioned (Donoghue and Kronfeld, 1990), however this opinion is unsupported by any data and is contrary to experimental studies (Russel et al., 1977). The report by Russel (1985) forms the basis of sheep preventive medicine visits during late pregnancy (see for example Hosie, 1989).

The interpretation of urinary ketone bodies is only an approximate guide to energy intake as a linear relationship does not exist between blood and urinary ketone body concentrations (van Horber, Mader and Jucker, 1980). Using Rothera's reagent, the presence of urinary ketones has limited application as a field test for ovine pregnancy toxæmia.

Critical evaluation of the practical usefulness of metabolic profile testing of ewes during late gestation requires an understanding of glucose, protein and fat metabolism in the ruminant species.

### **3.22.1 FAT METABOLISM**

During phases of liveweight gain body fat (triglyceride) is deposited preferentially in the following sites; perirenal tissue, omentum, intramuscular depots and in the subcutaneous layer (Parker and Herbert, 1976) with the latter quantitatively the most important (Berg, Jones, Price, Fukuhara, Butterfield and Hardin, 1979). The action of lipoprotein lipase on triglyceride stores (lipolysis) releases the acyl and glycerol moieties into the vascular system (Palmquist, 1976). Normal plasma glucose concentration inhibits lipolysis by stimulating re-esterification of fatty acids (Metz and van den Bergh, 1977). Numerous workers report the inverse relationship between plasma glucose and free fatty acid concentrations in dairy cows (Schwalm and Schultz, 1976; Scott, 1982). An elevated serum concentration of the ketone body 3-OH butyrate has an inhibitory effect on lipolysis (Metz, Lopez Cardozo and van den Bergh, 1974). Despite the level of feeding to cows in early lactation, some net utilisation of body fat appears to be a normal phenomenon (Lotan and Alder, 1976; Henricsson, Johnsson and Pehrson, 1977; West, 1988).

### **3.22.2 GLYCEROL**

Free glycerol concentrations in serum is an accurate indicator of lipolysis (Henricsson et al., 1977; Hardarson, 1980; Pike and Roberts, 1980) and has been used in field studies to assess nutritional status of dairy cows in early lactation (Hardarson, 1980).

In well-fed ewes glycerol released from fat depots probably accounts for less than 5% of glucose production (Bergman, Starr and Reulein, 1968), but reaches almost 40% in either fasted or ketotic sheep (Bergman, 1973). Glycerol is therefore an important glucose precursor in the underfed ewe and in those ewes with large litters.

### **3.22.3 NON-ESTERIFIED FATTY ACIDS (NEFAS)**

In dairy cows non-esterified fatty acids (NEFAs) are released into the circulation by the action of lipase in response to the negative energy status of early lactation (Brumby, Anderson, Tuckley, Storry and Hibbitt, 1975; Reid, Baird and Heitzman, 1977).

The serum NEFA concentration is considerably influenced by excitement and handling stress (Holmes and Lambourne, 1970) which reduces the application of this assay (Erfle, Fisher and Sauer, 1974). Despite this, numerous studies indicate the usefulness of this determination as a guide to energy status in lactating dairy cattle (Roberts, Reid, Dew, Stark, Baird, Collins and Mather, 1978; Dale, Vik-Mo and Fjellheim, 1979).

### **3.22.4 GLUCOSE**

Quantitatively, the major glucose precursor in ruminant digestion is the volatile fatty acid propionate acid which is one of the products of cellulose breakdown in the rumen. Altered volatile fatty acid production in favour of propionate by the addition of monensin sodium in the ration of dairy cows is useful in the prevention of bovine ketosis (Rogers and Hope-Cawdrey, 1980). This may be an important consideration due to the widespread administration of monensin to ewes during late pregnancy to control ovine toxoplasmosis. Following absorption

propionate is utilised in the gluconeogenesis pathway in the liver (Bergman, 1973; Pehrson and Knutson, 1980). In addition to propionate, glycerol and most amino acids are glucogenic and are utilised during periods of increased glucose demand. In ketotic sheep pregnant with twins, the amount of glucose synthesised from glycerol is markedly increased (Ranaweera, Ford and Evans, 1981).

Most research work relating to metabolic profile tests has concentrated on bovine ketosis in dairy cows during early lactation. During early lactation lactose secretion by the mammary gland is the major demand for glucose from the gluconeogenic pathway. Glucose is also the major metabolite used by the foetus (Mellor, 1983). In the pregnant ewe ovine pregnancy toxemia results from the high foetal demand caused by the rapid growth of two or more foetuses during the last six weeks of pregnancy. The larger the foetal burden the more susceptible the ewe is to hypoglycaemia during a period of underfeeding (Mellor, 1983). Although there are similarities in the metabolic pathways involved in ketosis and ovine pregnancy toxemia there is a fundamental physiological difference between them, namely that in the lactating dairy cow a reduction in milk yield reduces the glucose demand from the mammary gland. Such a reduction in milk yield allows the cow to return to a positive energy status. Conversely, in the pregnant ewe, unless the ewe aborts the glucose demand increases as the foetuses grow with advancing pregnancy. During late pregnancy a large proportion of maternal glucose is used by the uterus and its contents (Hodgson, Mellor and Field, 1982).

Bearing in mind what has been reviewed above, the stage of lactation in relation to peak milk yield is important when sampling cows for plasma

glucose concentrations. If the cows are past their peak milk yield or have a relatively low milk yield then glucose demand will be low and a poor correlation may be obtained between the calculated energy status and plasma glucose concentration. This may in part explain some of the differences in the literature; some authors report that the plasma glucose concentration is strongly influenced by a negative energy balance (Fisher, Donnelly, Hutton and Duganzich, 1975; Dale et al., 1979) and can be used to assess energy status in dairy cattle. However, numerous authors have questioned the practical value of plasma glucose concentration estimations in detecting inadequate energy intake (Erfle et al., 1974; Lee, Thardock, Burbar, Hall and Davis, 1978).

### **3.22.5 3-OH BUTYRATE**

Increased lipolysis and the incomplete oxidation of the 2-carbon radical due to a relative lack of oxaloacetate in the tricarboxylic acid (TCA) cycle leads to a build up of aceto-acetyl CoA. Hydrogenation of aceto-acetyl CoA results in the formation of 3-OH butyrate with acetone formed by decarboxylation. 3-OH butyrate is central in both fatty acid and glucose metabolism and has been studied as an indicator of energy balance in dairy cow nutrition (Kelly, Whitaker and Smith, 1988). In this respect epidemiological data reveal that dairy herds with a high incidence of clinical ketosis have significantly higher mean serum 3-OH butyrate than herds with a low incidence (Herdt, Stevens, Olson and Larson, 1981; Miettinen, 1990). In studies of bovine ketosis there is a significant inverse relationship between energy balance and serum ketone body concentration (Dale et al., 1978; Hardarson, 1980). Studies which report a poor correlation between these variables often involve moderate milk yields in cows which are beyond peak yield (Erfle et al., 1974; Fisher, 1979).

A significant inverse relationship exists between serum 3-OH butyrate and plasma glucose concentrations (Hove and Halse, 1978; Fronk, Schultz and Hardie, 1980). The correlation between the serum concentrations of the ketone bodies acetoacetate and 3-OH butyrate is highly significant (Kronfeld, Donoghue, Naylor, Johnson and Bradley, 1980).

In those studies with dairy cows where the serum 3-OH butyrate concentration increased following feeding (Coggins and Field, 1976; Hove and Halse, 1978; Manston, Rowlands, Little and Collins, 1981) such increases in concentration were small and do not alter the interpretation of data. Under certain circumstances high dietary butyric acid content and subsequent conversion to 3-OH butyrate in the rumen epithelium may increase the serum concentration (Weigand, Young and McGillard, 1972). This may be an important consideration in ruminants fed poorly-fermented silage.

Weekly monitoring of plasma 3-OH butyrate concentration in pregnant Blackface ewes as a measure of dietary adequacy has been described (Russel et al. 1967a and 1967b). Weekly monitoring of plasma 3-OH butyrate concentration and adjustment of the dietary metabolisable energy allowance of pregnant Greyface ewes into categories of adequately fed, moderately and severely underfed resulted in significant reductions in lamb birthweight in both single and twin bearing ewes (Russel et al., 1977). This work has been widely adopted as a guide to feeding levels of ewes during late pregnancy: serum concentrations of 3-OH butyrate of less than 0.7, 0.8-1.6, and more than 1.6mmol/l represent adequate, moderate underfeeding and severe underfeeding respectively (Russel, 1985).

In dairy cow metabolic studies, Herdt et al. (1981) reported that serum ketones are an important energy source. Urinary excretion data (von Horber et al, 1980) suggested a serum threshold level of 1.6mmol/l for 3-OH butyrate, thereafter further increases in serum concentration result in a rapid rise in urinary excretion. This threshold concentration of 1.6 mmol/l of 3-OH butyrate is in good agreement with the definition of severe-underfeeding proposed by Russel et al. (1977) and may indicate inefficient use of mobilised body fat reserves.

### **3.22.6 SERUM FRUCTOSAMINE**

Fructosamine is a stable keto-amine formed when glucose reacts non-enzymatically with amino groups on proteins. A recent field investigation of an outbreak of ovine pregnancy toxemia (Cantley, Ford and Heath, 1991) details the use of serum fructosamine concentration as an useful prognostic index of ovine pregnancy toxemia. These authors concluded that serum fructosamine concentrations might be used as an early indicator of impending pregnancy toxemia when the serum 3-OH butyrate concentrations are still within normal limits.

### **3.23.1 PRODUCTION DISEASES RELATED TO FATNESS AT PARTURITION**

The suggestion that overweight ewes present with ovine pregnancy toxemia, dystocia or ketosis in early lactation (Donoghue and Kronfeld, (1990) is unsupported by clinical data. One proposed reason for the aetiology of such diseases is that because of massive abdominal fat and rapid digesta times (Graham and Williams, 1962) these ewes are unable to meet the increasing energy requirements of advancing pregnancy. Another factor could be the depressed voluntary food intake of fat ewes compared to controls (Cowan, Robinson, McDonald and Smart, 1980). However, Reid and Hinks (1963) reported that ewes in good body condition were



more able to maintain blood glucose concentrations when underfed than thin ewes.

In dairy cattle, reports state that cows which are excessively fat at parturition are more prone to metabolic disease (Morrow, 1976; Fronk et al., 1980) but a similar situation has not been reported for sheep. This species difference may be because in cows there is a rapid demand for glucose following calving to synthesise lactose compared to a more gradual increase in glucose demand in the sheep from the growing fetuses.

In dairy cattle improved body condition at calving was associated with higher lactation yields; Frood and Croxton (1978) and Land and Leaver (1980) reported that cows with a condition score greater than 2.5 gave significantly more milk than those with a score less than 2.0. Murray, Smith and Harker (1981) reported that poor cow condition results in an increased incidence of post-calving diseases.

In an epidemiological study of vaginal prolapse the statement by Hosie (1989) that the presence of fat ewes (body condition score greater than 3.0) and a mean serum 3-OH butyrate concentration of less than 0.8mmol/l is consistent with over feeding is incomplete and should not be a basis for reducing energy allowance to pregnant ewes in a lowground flock. In order to achieve the target mean 3-OH butyrate concentration of 1.1mmol/l by reducing concentrate allowance some ewes, probably those bearing triplets, could become severely underfed ( $>1.6\text{mmol/l}$ ). The implications of an outbreak of ovine pregnancy toxaemia are considerably greater than those for cases of vaginal prolapse.

### 3.24.1 PROTEIN METABOLISM

While the ewe's crude protein requirements increase during the last six weeks of gestation (Clarkson and Faull, 1987) the direct consequences of inadequate dietary crude protein supply on lamb birthweights or ewe colostrum accumulation have not been as extensively studied as the effects of dietary energy supply. It is generally assumed that if a 16% crude protein concentrate is fed to meet the ewe's metabolisable energy requirements, then protein requirement will be similarly met.

### 3.24.2 ALBUMIN

As dietary protein intake exerts a major influence on the serum albumin concentration (Rothschild and Oratz, 1976) serum albumin concentration can be used as an indicator of long term protein status.

In dairy cow studies the serum albumin concentration one week post-partum shows a significant inverse relationship with the hepatocyte fat content (Reid, Roberts and Manston, 1979). As albumin is synthesised solely in the liver, reduced serum concentrations may indicate impaired liver function due to fatty infiltration. No such studies have been carried out in pregnant sheep.

Chronic infections in individual animals can result in a marked reduction in serum albumin concentrations but this would not influence the group mean serum albumin concentration. On a flock basis, sub-acute and chronic infections with Fasciola hepatica are a common cause of hypo-albuminaemia (Skyes, Coop and Robinson, 1980b) in sheep grazing endemic liver fluke areas.

### **3.25.1 CENTRAL NERVOUS SYSTEM FUNCTION IN NEONATAL LAMBS**

As outlined in a previous section, central nervous system function during the first days of life has been studied most thoroughly in foals (Adams and Mayhew, 1985). Normal ovine neonatal behaviour such as the time to stand and teat searching is considerably influenced by the breed, duration of second stage labour, lamb birthweight and adverse weather conditions. A normal lamb would be expected to stand and suck vigorously within ten minutes of birth. Once a lamb has sucked colostrum it will normally seek out a sheltered area and maintain sternal recumbency. After six hours of age the behaviour of the neonatal lamb is significantly influenced by prevailing weather conditions and, most importantly, whether it has sucked sufficient colostrum. Impairment of physiological processes such as thermogenesis and maintenance of plasma glucose concentrations can cause abnormal states such as lethargy, failure to suck, progressing to coma and death. Response to warming and intraperitoneal glucose injection is good in primary cases of hypothermia or hypoglycaemia but advanced cases of endotoxaemia have a much poorer prognosis.

Gross examination of the central nervous system at necropsy is time-consuming and the findings are often difficult to interpret. For this reason collection and examination of cerebrospinal fluid may provide useful additional information, in particular as an indicator of sub-arachnoid haemorrhage.

### **3.25.2 CEREBROSPINAL FLUID FORMATION**

The formation of CSF results from ultra-filtration of blood plasma and active transport of selected compounds across the blood brain-barrier (BBB) (Cserr, 1971; Milhorat, 1975). When the BBB integrity is damaged

the normal molecular weight cut-off, around that of albumin, is disrupted with consequent transudation of plasma proteins into the CSF in a ratio proportional to their molecular weight and plasma concentration (Delmonte and Carton, 1981).

### **3.25.3 NORMAL VALUES OF CEREBROSPINAL FLUID**

Normal cerebrospinal fluid is a clear, colourless fluid with a protein concentration less than 0.4g/l and a white blood cell count of  $0.012 \times 10^9/l$  comprised almost exclusively of lymphocytes. (Scott, 1992).

### **3.25.4 HAEMORRHAGE WITHIN THE CENTRAL NERVOUS SYSTEM**

Haemorrhage is identified by the presence of erythrocytes in the cerebrospinal fluid. This will be evident as a pink, turbid appearance when the erythrocyte count exceeds  $400/\mu l$  (Todd, Sanford and Donaldson, 1984). Haemorrhage during the sampling procedure results from penetration of a subdural sinus and occurs either when syringe aspiration of cerebrospinal fluid begins or if the animal moves altering the position of the needle.

Blood contamination due to a traumatic tap is usually not homogeneous and usually decreases as further fluid is withdrawn (Hayes, 1987). A sample heavily contaminated by traumatic haemorrhage will frequently clot (Calabrese, 1976). In addition, artifactual haemorrhage clears after centrifugation (Tvedten, 1987). Haemolysis occurs within one to four hours of haemorrhage into the CSF and this pink colouration does not clear after centrifugation (Kjeldsbert and Krieg, 1984).

Lysis of red blood cells is thought to be due to membrane instability when exposed to fluids of a low protein concentration. Xanthochromia is

the presence of a yellow-orange pigment which appears approximately 48 hours after haemorrhage within the cerebrospinal fluid and may persist for up to three to four weeks (Mayhew and Beale, 1980). In many vascular diseases there is typically leakage of protein and some xanthochromia with significant pleocytosis if the haemorrhage is marked (Mayhew, 1989). Mayhew (1989) states that neonates may have slightly xanthochromic cerebrospinal fluid but no units are quoted. Pathological haemorrhage in cerebrospinal fluid is most confidently diagnosed by erythrocyte phagocytosis and the presence of haemosiderin in histiocytes (Tvedten, 1987).

### **3.25.5 CEREBROSPINAL FLUID PRESSURE**

Normal cerebrospinal fluid pressures have not been determined in neonatal lambs.

Normal equine cerebrospinal fluid pressure measurements are variable and are largely influenced by technique and blood pressure (Hayes, 1987). In one study the normal cerebrospinal fluid pressure range was 150 to 500mm H<sub>2</sub>O with a mean of 308mm H<sub>2</sub>O (Mayhew, Whitlock and Tasker, 1977). It is unlikely that satisfactory cerebrospinal fluid pressure readings could be performed in the ovine neonate and because of the large variation in equine values such results could be difficult to interpret.

### **3.26.1 WEAK CALF SYNDROME**

Calf mortality rates vary between breeds and dam parity but are particularly high in heifers. For Dutch Holstein heifers the stillborn rate and dystocia mortality rate were particularly high at 10.5 and 19.8% and for second calvers 3.2 and 9.6% respectively; for Groningen Whitehead the percentages were 17.6 and 23.5% for heifers and 2.6 and

7.3% for second calf cows (Gruys and Olson, 1991). Such dystocia mortality rates are wholly unacceptable and a review of breeding policy would appear overdue.

The term "weak calf syndrome" (Mee, 1991) refers to those calves which die within 48 hours of birth from a gestation period greater than 260 days. A study of 100 calves with this syndrome reported that 90% were alive at the start of second stage labour but 80% of the calves died within five minutes of birth (Mee, 1991). As 66% of births were associated with a dystocia frequently requiring the use of "calving aids", Mee (1991) concluded that the primary cause of the weak calf syndrome/bovine perinatal mortality on Irish dairy farms is dystocia. Support for dystocia as a major factor in weak calf syndrome is provided by necropsy data which revealed that in stillborn calves or those which failed to breathe at birth there was evidence of thoracic trauma, subcutaneous oedema and haemorrhages over and within the carpal and tarsal joints (Simpson, 1990).

The prolonged duration of the first and second stages of labour in cases of "weak calf syndrome" has also been reported (Rice, McMurray, Kennedy and Ellis, 1986; Sluijter, Zimmer and Wouda, 1990). In addition, Sluijter et al. (1990) reported that the placenta is expelled together with the calf. This is unusual if a calving problem is involved in the aetiology of weak calf syndrome as dystocia is generally associated with retention of the foetal membranes (Erb, Smith, Oltenacu, Guard, Hillman, Power, Smith and White, 1985). Based on the data available Sluijter et al. (1990) could not differentiate between premature placental separation or extended first and second stage labour. Further analysis

of these data (Gruys and Olson, 1991) suggest that inadequate supervision leading to prolonged duration of parturition is responsible.

On the contrary, a recent report by Logan, Smyth, Kennedy, Rice and Ellis (1991) described an emerging problem of stillbirth and perinatal weak calf syndrome which was considered to be an acute condition of calves after 270 days' gestation, characterised by a failure to sustain breathing at parturition (Rice et al., 1986). No evidence of trauma was noted at necropsy. In this situation, epidemiological data suggested a possible trace element deficiency state because of the total reliance on home produced forages to form the majority of the ration. In this particular clinical situation the administration of iodine parenterally to pregnant cows markedly reduced the incidence of stillbirths (Logan et al., 1991). The extent to which a similar clinical situation exists in sheep flocks remains to be investigated. The feeding of correctly-mineralised concentrates during the last 6-10 weeks of pregnancy may prevent such a deficiency developing in sheep flocks.



## **4.0 MATERIALS AND METHODS**

### **4.1.1 COMMERCIAL FLOCK SURVEY**

The flocks included in this survey were lowground flocks in East Central Scotland lambing from February until April. Flock size varied from 250 to 1,000 ewes. The majority of farmers drafted their ewes after four crops of lambs although some farms kept sound ewes for up to seven crops. Soundness referred to normal udder conformation with no evidence of previous mastitis, good body condition and no molar teeth abnormalities. Less attention was paid to incisor tooth wear. Most flocks were housed during the last four to eight weeks of gestation. Some flocks were confined to "lambing paddocks" comprising small fields adjacent to farm buildings prior to lambing and then housed one week before lambing commenced. Housing was considered to be an important management factor common to all of the flocks in this study because such flocks would encounter similar levels of environmental challenge from viruses, protozoa and bacteria.

Thirty flocks were included in this study and comprised two Suffolk flocks, two Blackface flocks, two Scottish Halfbred flocks, one Cheviot flock and 23 Scottish Mule and Greyface flocks. All flocks were serviced by the Large Animal Practice, Royal (Dick) School of Veterinary Studies, Edinburgh. The majority of flocks were studied over a two year period. One flock was monitored in detail over five years.

### **4.1.2 FEEDING**

Silage was the sole roughage fed on three farms. Turnips were fed at various stages of late gestation on 23 of the 30 farms with the majority of farms folding pregnant ewes on turnips for two to four hours per day. Hay was the only roughage fed on six farms.

Purchased compound feeds were fed on eight farms. These compound feeds had a declared crude protein concentration of 16% with a fibre content of between 6-12%. No metabolisable energy concentration was declared by any of the compound feed manufacturers nor were the constituents declared. The farmers who purchased compound feeds equated cost per tonne with quality. A 16% crude protein ration cost approximately £140/tonne delivered in 25kg paper sacks and an 18% crude protein pellet £160-180/tonne. On the remaining 22 farms concentrate feeding was based on home-grown barley supplemented with purchased soya bean meal and fish meal. Typically, 150kg soya bean meal was added to 850kg barley and fed throughout late gestation with 2.5-5.0% fish meal added to the ration during the last two weeks of gestation and throughout early lactation. Concentrates were fed in a step-rate manner commencing six to ten weeks before lambing. In some flocks a small amount of concentrate was fed throughout mid pregnancy to ensure an intake of 10mg per day of monensin sodium in an attempt to control abortion caused by Toxoplasma gondii. Few flocks were fed concentrates at a flat rate during late pregnancy.

#### **4.1.3 CONDITION SCORING**

Ewe condition scoring was performed using the guidelines outlined by Jeffries (1961) and White and Russel (1984). Between 10-30% of the flock were condition scored by the author at the routine veterinary advisory visit four to six weeks prior to lambing. Additional data on ewe body condition scores at mating time and at stages throughout gestation had also been collected on three farms.

#### **4.1.4 POST MORTEM EXAMINATION**

Post-mortem examinations were performed using the methodology described by Hindson and Winter (1990). Particular attention was paid to the

report by Rook et al., (1990) concerning the diagnosis of starvation, mismothering, exposure. This excellent practical paper emphasises examination of:

- i) the extent of fat mobilisation. In the newborn lamb the kidney is surrounded by firm, white, perirenal fat. There is rapid mobilisation of perirenal fat in starvation cases and the kidney is readily visible, surrounded by "wet" perirenal tissue indicative of considerable fat mobilisation. Other fat stores such as the omentum also present with this "wet" appearance in starvation cases.
- ii) the presence of clotted milk in the abomasum. This clotting mechanism indicates that the milk had sufficient time to clot in the abomasum, i.e. stomach tubing with milk was not an agonal event. If the lacteals are white beyond the level of the mesenteric lymph nodes this indicates active intestinal absorption of milk from the small intestine.
- iii) the presence of considerable yellow subcutaneous oedema of the head and limb extremities are indicative of dystocia or exposure.

The diagnosis of watery mouth is based on necropsy findings of marked distention of the abomasum with mucoid material and gas. The intestines are empty except for gas accumulation. Mesenteric lymph nodes are enlarged and active. There is a variable degree of fat mobilisation. The carcase has a dehydrated appearance and there is evidence of profuse salivation.

#### **4.1.5 BLOOD SAMPLE COLLECTION AND ANALYSIS**

In order to determine the prevalence of ewe underfeeding during late gestation in commercial sheep flocks in East Central Scotland, 30 flocks were visited in February or March over a two year period. Forty-seven sets of data were collected, i.e. 17 flocks were sampled in consecutive years.

At three to five weeks prepartum a representative number of animals was selected at random from those ewes due to lamb within the first week of the lambing period. Any sheep with evidence of lameness or ill health was excluded. Ewes from all age groups were selected and approximately 15-20 ewes were blood sampled. Blood samples were collected by jugular venepuncture into 7ml plain vacutainers for all determinations except for glucose estimations when oxalate/fluoride vacutainers were used.

Serum total protein and albumin concentrations were calculated using the Technicon RA-Xt auto-analyser. Serum 3-OH butyrate concentration was determined using an automated adaption of the method of Zivin and Snarr (1973). Plasma glucose concentration was determined within two hours of sample collection using a Technicon RA-Xt auto-analyser.

#### **4.1.6 CEREBROSPINAL FLUID COLLECTION AND ANALYSIS**

Cerebrospinal fluid samples were collected from lambs, using the methodology described by Scott and Will (1991), to investigate the incidence of subarachnoid haemorrhage in the aetiology of perinatal disease. Cerebrospinal fluid samples were collected from lambs suffering from various bacterial diseases including poly-arthritis, meningitis and epidural spinal abscessation.

Cerebrospinal fluid was examined grossly for red blood cells and the presence of a red colour indicative of xanthochromia, the pigment released following haemolysis of red blood cells in the cerebrospinal fluid. Xanthochromic change was differentiated from haemorrhage by centrifugation of the cerebrospinal fluid sample or by allowing the cerebrospinal fluid sample to stand for two hours in the laboratory. In haemorrhagic samples the red blood cells sediment out leaving the normal, clear CSF sample.

Cerebrospinal fluid specific gravity was determined using a hygrometer. Total white blood cell counts in cerebrospinal fluid were performed on a haemocytometer. For differential white blood cell counts counts, cerebrospinal fluid samples were first concentrated by cytopspin within two hours of collection and stained with Leishman stain. The differential count was based on a minimum of 20 cells.

#### **4.1.7 LAMB BIRTHWEIGHTS**

Lamb birthweights were recorded before the lamb sucked colostrum using a spring balance accurate to  $\pm 100\text{g}$ . On three farms placentae were collected after the completion of third stage labour and weighed on an electronic balance accurate to  $\pm 10\text{g}$ . As it was not possible to assign a particular placenta to a particular lamb in the case of multiple births, an average placental weight for each lamb in the litter was calculated. The number of cotyledons was counted by incising the placenta to form a two dimensional sheet rather than the normal cylindrical shape. The diameter of individual cotyledons was measured with calipers accurate to 1mm.

## 4.2 ABORTION

### 4.2.1 INVESTIGATION OF ABORTIFACIENT AGENTS

Whenever possible placentae and aborted foetal material, in addition to a blood sample from the dam, were submitted for laboratory examination. Bacteriological culture of foetal stomach contents was undertaken to check for the presence of such abortifacient agents as salmonellae spp. and Campylobacter jejuni.

### 4.2.2 C. PSITTACI VAR OVIS LABORATORY TESTING

C. psittaci var ovis has been the most common cause of ovine abortion on farms serviced by the Large Animal Practice for the past 10 years. The common pattern is that of an abortion rate of 2-10% within the flock. The abortion rate is usually highest in one-crop ewes which lambed in the flock for the first time the previous year as gimmers.

Abortion of well-preserved lambs during the last two to three weeks of gestation and an associated necrotic placentitis provide reasonable grounds for the diagnosis of chlamydial abortion (Aitken, 1983). Large numbers of chlamydial elementary bodies can be demonstrated in smears made from affected cotyledons and stained with a modified Ziehl-Neelsen procedure. Alternatively, direct smears from the wet fleece of a recently aborted or stillborn lamb can be used.

Serology can be employed in the diagnosis of chlamydial abortion but the interpretation of such a result may be complicated by vaccination titres. A titre greater than 2/32 is generally considered indicative of recent chlamydial infection. Paired serology with the first sample taken at the time of abortion and a second sample two weeks later demonstrating a rise in the convalescent titre is the most useful

serological method of investigating a potential chlamydial abortion problem.

There is no conclusive laboratory test to identify the significance of chlamydial infection in those lambs which are carried to full term. Laboratory tests such as serological testing of all ewes in a flock or Giemsa-stained smears of the lamb's coat have not been reported in the literature. Interpretation of maternal serological tests performed at fullterm for chlamydial infection in field outbreaks of disease would be difficult in the absence of such reference data.

#### **4.2.3 C. PSITTACI VAR OVIS ABORTION FIELD TRIALS**

In an attempt to avoid problems with the interpretation of chlamydial infection in a flock by serological testing of the dam, the effect of administration of an antibiotic to ewes three weeks prior to lambing in flocks with a history of C. psittaci abortion was compared to a control group of sheep in the same flock which received no treatment. The injection of a long-acting antibiotic preparation would be expected to limit the extent of the chlamydial placentitis, thus allowing a more normal transplacental exchange of nutrients during the critical last three weeks of gestation. Such treatment would be expected to result in increased lamb birthweights and increased lamb viability compared to untreated ewes infected with C. psittaci.

The study of antibiotic therapy during late gestation involved ten farms in the first year. Each farm had a history, including the previous year, of an abortion rate greater than 2% caused by C. psittaci. The sheep were allocated to one of three groups:



- Group 1 control, no treatment;
- Group 2 received an intramuscular injection of Engemycin 10% DD(R), Mycofarm, (100mg oxytetracycline/ml) at a dose rate of 16mg/kg;
- Group 3 received a subcutaneous injection of Tylan(R), Elanco (200mg/ml tylosin) at a dose rate of 10mg/kg.

The antibiotic treatments were administered three weeks before the expected lambing dates which were based on the ram keel markings.

A similar study was undertaken the following year. In the second year the tylosin treatment was replaced by a long-acting oxytetracycline preparation. Six farms were involved in the study as outlined below.

- Group 1 control, no treatment;
- Group 2 16mg/kg oxytetracycline (Engemycin 10% DD(R), Mycofarm) administered intramuscularly;
- Group 3 20mg/kg oxytetracycline (Terramycin LA(R), Pfizer) administered intramuscularly.

#### LABORATORY METHODS FOR DEFINING OTHER SPECIFIC CAUSES OF ABORTION:

##### 4.2.4 TOXOPLASMA GONDII

Infection of a susceptible sheep with Toxoplasma gondii during mid-pregnancy commonly results in the birth of a stillborn or weakly lamb together with a small mummified foetus and diseased placenta. An

indirect haemagglutination titre greater than 1/1280 at the time of abortion was considered to indicate recent toxoplasma infection.

#### **4.2.5 SALMONELLA SPECIES**

Confirmation of diagnosis of salmonellosis depends upon the isolation of the causal organism from aborted foetal stomach contents. Growth of Salmonella spp. on desoxycholate citrate agar (DCA) can be followed by species identification by agglutination tests.

#### **4.2.6 CAMPYLOBACTER SPECIES**

Diagnosis of campylobacteriosis can be made on smears of aborted foetal stomach content stained with strong carbol fuchsin and by growth under selective conditions with subsequent identification by microscopic examination.

### **4.3 WOODHOUSELEA GREYFACE EWE TRIAL**

#### **4.3.1 ANIMALS**

Each of the animals in this trial had been identified as twin-bearing by real-time ultrasound scanning performed around day 60 post-mating. The sheep were housed for a minimum of the last eight weeks of pregnancy in a purpose-built, single-span sheep shed. The animals were allocated to eight treatment groups and kept in batches of 30. The shed was bedded twice weekly with wheat straw with a floor space allowance of 1.4m<sup>2</sup>/ewe.

#### **4.3.2. DIET**

The dietary experimental design was part of a research project undertaken by Drs Vipond and Lewis, Scottish Agricultural Colleges, to investigate the influences of draff and different types of silage conservation on the performance of Scottish Greyface ewes during late

gestation. The nutritional management of this flock was outwith my control. The details of the experimental diet are included in Table 1. The diets were designed to provide 15 MJ ME/head/day during the last four weeks of gestation. Such diets would be similar to the energy allowance of pregnant ewes in commercial farms.

TABLE 1

Daily dietary constituents (fresh basis) of nutritional treatments at Woodhouselea

Treatment	<u>Feeding Period</u> Weeks before lambing	Draff (g)	Silage (g)	Barley (g)	Fishmeal (g)
1. Silage/barley	8-4 4-0	- -	Ad lib Ad lib	- 400	- 50
2. Silage/draff	8-4 4-0	- 1600	Ad lib Ad lib	- -	- -
3. Draff/barley	8-4 4-0	4500 4500	- -	- -	- -
4. Draff/draff	8-4 4-0	4500 Ad lib	- -	- -	- -
5. Control silage	8-4 4-0	- -	Ad lib Ad lib	- 600	- -
6. Control silage	8-4 4-0	- -	Ad lib Ad lib	- 600	- -
7. Maxgrass	8-4 4-0	- -	Ad lib Ad lib	- 300	- -
8. Maxgrass	8-4 4-0	- -	Ad lib Ad lib	- 300	- -

#### 4.3.3 LIVEWEIGHT AND CONDITION SCORE MONITORING

The ewes were weighed and condition scored on three occasions at eight and four weeks prepartum and at parturition.

#### **4.3.4 BLOOD SAMPLE COLLECTION**

Blood samples were collected approximately four weeks prepartum and during the last week of gestation and prepared and analysed as previously described.

#### **4.4 OCCURRENCE OF ILLNESS DURING LATE GESTATION**

All cases of illness during the last two months of pregnancy were examined by a veterinary surgeon.

##### **4.4.1 VAGINAL PROLAPSE**

Cases of vaginal prolapse were thoroughly cleaned, carefully replaced and retained in position by a Buhner suture using 5mm nylon tape. This procedure was performed under caudal epidural anaesthesia. Following replacement of the vaginal prolapse 2mls of flunixin meglumine (Finadyne(R), Kirby Warwick) was injected intravenously. An injection of long-acting oxytetracycline was administered to those cases where there was a significant amount of superficial infection or trauma of the prolapsed tissues.

##### **4.4.2 OVINE PREGNANCY TOXAEMIA**

Ovine pregnancy toxemia was diagnosed when the following set of clinical criteria was met: sudden onset of inappetance, dullness, apathetic appearance; blindness, head-pressing which are consistent with an hepatic encephalopathy and that no other abnormalities could be detected on clinical examination. Confirmation of the diagnosis of ovine pregnancy toxemia was based on a serum 3-OH butyrate concentration above 4.0mmol/l. In the event that the ewe failed to respond to treatment, necropsy of ovine pregnancy toxemia cases revealed fatty infiltration of the parenchymatous organs especially the

liver and the presence of two or more well-developed fetuses in-utero. No other pathological changes were observed.

All cases of ovine pregnancy toxemia were treated with concentrated oral electrolyte solution b.i.d. (Liquid Lectade(R), Smith Kline Beecham) and a single injection of 16mg dexamethasone (Soludex(R), Mycofarm).

Cases of listeriosis were diagnosed in those animals which presented with neurological signs indicative of a brainstem lesion. These signs included hemiparesis, circling and cranial nerve dysfunction primarily involving the trigeminal and facial nerves. Cerebrospinal fluid samples revealed an elevated protein concentration and mild neutrophilic pleocytosis.

#### **4.5 DATA COLLECTED AT PARTURITION**

##### **4.5.1 DYSTOCIA**

The occurrence, cause of all dystocia cases and their correction were recorded.

##### **4.5.2 LAMB BIRTHWEIGHTS**

Lamb birthweights were recorded before the lambs sucked colostrum.

##### **4.5.3 STILLBIRTHS**

The occurrence of stillbirths was noted. Stillbirth was confirmed by the absence of normal inflated lung tissue which, when tested, floats in water whereas atelectic lung tissue, present in the case of stillbirth, sinks.

#### 4.5.4 PLACENTAE

Placentae were collected after the completion of third stage labour and sealed in polythene bags until weighed later that day.

#### 4.5.5 TIME OF PARTURITION

There was constant 24 hour per day attendance by farm staff throughout the lambing period. The time of parturition was recorded in two hourly-intervals.

#### 4.5.6 MANAGEMENT AFTER PARTURITION

Ewes were penned with their lambs immediately following completion of second stage labour in individual pens measuring 1.6mx1.6m. Each lamb was treated orally with 70mg neomycin and 70mg streptomycin (Orojet(R), Willows Francis) within the first 30 minutes of life. The umbilical cord was fully immersed in strong iodine solution B.P. Each lamb was examined at six hours old to ensure that it had sucked colostrum. As the abomasum accounts for up to 85% of fore-stomach capacity in newborn ruminants an assessment of abdominal distension by gentle digital palpation immediately caudal to the xiphisternum gives a reasonable guide to abomasal distension and hence to the amount of colostrum sucked. When lambs were identified as having failed to suck sufficient colostrum they were stomach-tubed with colostrum. If there was insufficient dam or donor ewe colostrum, bovine colostrum was used as a substitute. The dosage rate of colostrum was approximately 50mls/kg liveweight. It was important to administer the ovine colostrum at body temperature to ensure that it would flow down a stomach tube. This was most easily achieved by adding a small volume of hot water to the colostrum. This slightly diluted ovine colostrum flowed much more readily down an Osmond's stomach tube. When there was insufficient

ovine colostrum, bovine colostrum which had been frozen previously and stored for such needs was used as a substitute. This was slowly thawed and warmed to body temperature by immersing the 0.5-1.0 litre aliquots in hot water.

Despite the fact that all the ewes were scanned for twins approximately 20% of ewes produced triplets. In the event that a ewe lambed living triplets one lamb was removed at birth and fostered onto an ewe with a single lamb or else reared as an orphan lamb.

The ewe and lambs were transported to outlying grass fields 36-72 hours after birth.

#### **4.6 SUFFOLK FLOCK SURVEY**

The major object of this study was to investigate the relationship between placental measurements, lamb birthweight and perinatal mortality.

##### **4.6.1 ANIMALS**

The Woodhouselea Suffolk flock totals approximately 240 breeding females with equal numbers of gimmers and 1- and 2-crop pedigree Suffolk ewes. The ewes are grouped in pens of thirty sheep in a single-span, purpose-built sheep shed. Lambing takes place indoors during January and February. The level of stockmanship is exemplary and there is constant 24 hour per day attendance during the lambing period.

##### **4.6.2 DIET**

The pregnant sheep are fed concentrates in a step rate manner commencing with 300g/head/day six weeks before lambing and increasing to 600g and



900g/head/day at four weeks and two weeks pre-lambing respectively. Following lambing ewes are fed concentrates at 1.2 kg/head/day. Good quality hay is available ad libitum.

#### **4.6.3 MANAGEMENT**

Ewes were individually penned immediately following the completion of second stage labour. The lambs were weighed before they sucked colostrum and the navels treated with strong iodine solution B.P. The cause and severity of any dystocia case was noted. The occurrence of stillbirths and cases of perinatal mortality were recorded.

Placentae were collected immediately after the completion of third stage labour, sealed immediately in polythene bags and weighed that day. The number of cotyledons was counted and the diameter measured with calipers.

## **5.0 RESULTS**

### **5.1 COMMERCIAL FLOCK SURVEY**

#### **5.1.1 PERINATAL MORTALITY RATE**

On those farms where reliable figures could be obtained the perinatal lamb mortality rate varied from 3.0% to 15%. Three flocks produced consistently good results of around 3% perinatal lamb mortality each year. Factors which influenced the perinatal lamb mortality rate are described in more detail throughout the various sections of results.

The majority of farmers did not accurately record the number of dead lambs nor did they attempt to distinguish between stillbirths and those lambs born alive but which later died. Only two of the 30 flocks studied kept written records of lamb losses. On the other farms the shepherd recorded the number of ewes in the "singles" and "twins" fields after turnout.

The lack of detailed on-farm recording resulted in reliable figures being obtained from the various field trials that were undertaken in eight flocks. In the remaining flocks, during veterinary visits to the farm the number of live and dead lambs plus the number of ewes that had lambed were counted and the perinatal mortality rate calculated approximately.

#### **5.1.2 LEVEL OF STOCKMANSHIP**

There was a large range in the average number of ewes supervised by one person during the peak of the lambing period. The range extended from 80 ewes to 250 ewes per person. The median number was in the region of 130 to 150 ewes. It was not possible to accurately determine how many people were involved with the flock during the lambing period as other

farm duties such as cattle and spring crops were also variably attended to. For this reason exact figures were not calculated. In this survey one full time person was considered to work 12 hours per day, seven days per week.

While the number of people involved in supervising the flock could be approximated the level of competence and ability was very difficult to quantify objectively. Veterinary assessment of the general level of stockmanship was based on the production characteristics of the flock over many years, therefore it was not possible to investigate the relationship between lamb perinatal mortality and level of stockmanship because these parameters were not independent variables. A further problem in determining the level of flock supervision was that not all attendants had the same level of competence. An attempt to give a mean competence score was abandoned because it was too subjective. It was concluded that the level of competence was generally satisfactory but that the workload was too great and the facilities, particularly the lambing pens, were inadequate, further increasing workload.

## **5.2 DEFINITION OF LEVEL OF EWE NUTRITION**

Results of blood sample analyses and condition scoring were available for thirty flocks. The flocks were divided into three groups based on the flock mean 3-OH butyrate concentration (Russel et al., 1977). Seventeen flocks were sampled in two consecutive years which gave a total of 47 sets of data. In the two seasons the correlation of ewe energy status based on the mean serum 3-OH butyrate concentration was very high with all flocks classified in the same category as the previous year. There were 27 adequately-nourished flocks (serum 3-OH butyrate concentration less than 0.7 mmol/litre). The details of these

flocks are presented in Table 2. There were 17 Group 2 flocks which were classified as moderately-undernourished (between 0.7 and 1.6 mmol/litre) and one severely-undernourished flock (above 1.6 mmol/litre) shown in Table 3.

#### **5.2.1 DIAGNOSIS OF OVINE PREGNANCY TOXAEMIA**

Diagnosis of ovine pregnancy toxaemia was based on the presence of clinical signs of an hepatic encephalopathy and confirmed by a serum 3-OH butyrate concentration greater than 4.0 mmol/litre. Necropsy of ovine pregnancy toxaemia cases failed to reveal any significant findings except for poor bodily condition, moderate fatty infiltration of the parenchymatous organs, especially the liver, and the presence of two or more, well developed foetuses in utero. While these pathological findings are suggestive of ovine pregnancy toxaemia they are by no means pathognomic.

#### **5.2.2 OCCURRENCE OF CLINICAL CASES OF OVINE PREGNANCY TOXAEMIA**

No clinical cases of ovine pregnancy toxaemia were observed in Group 1 flocks but two out of seventeen (11.2%) Group 2 flocks and the single Group 3 flock experienced clinical cases of ovine pregnancy toxaemia (Table 4).

TABLE 2

Serum 3-OH Butyrate Concentrations in Group 1  
(adequately nourished) Flocks

Flock	mean (mmol/litre)	number sampled	Range (mmol/litre)	Flock size
1	0.51	16	0.44 - 0.67	700
2	0.40	18	0.23 - 0.88	250
3	0.40	18	0.23 - 0.89	810
4	0.60	6	0.43 - 0.83	150
5	0.60	14	0.28 - 1.21	450
6	0.62	6	0.48 - 0.95	30
7	0.57	17	0.43 - 0.78	800
8	0.55	17	0.42 - 0.89	200
9	0.50	17	0.41 - 0.87	150
10	0.60	9	0.48 - 0.74	40
11	0.58	16	0.36 - 1.00	400
12	0.35	17	0.20 - 0.67	850
13	0.40	20	0.17 - 0.51	850
14	0.30	7	0.20 - 0.70	300
15	0.50	14	0.16 - 1.12	120
16	0.50	15	0.22 - 0.89	200
17	0.55	9	0.37 - 0.94	30
18	0.50	6	0.35 - 0.65	350
19	0.40	12	0.10 - 1.50	600
20	0.60	15	0.40 - 0.93	300
21	0.55	13	0.24 - 2.27	1200
22	0.60	18	0.20 - 1.50	900
23	0.60	15	0.37 - 1.61	700
24	0.40	13	0.33 - 0.46	700
25	0.49	7	0.17 - 0.66	350
26	0.51	12	0.34 - 0.70	150
27	0.54	17	0.24 - 2.1	650

TABLE 3

Serum 3-OH butyrate concentrations in  
Group Two (moderately underfed) flocks

Flock	mean (mmol/litre)	number sampled	Range (mmol/litre)	Flock size
1	1.18	12	0.38 - 4.84	150
2	0.73	7	0.50 - 1.23	150
3	0.77	12	0.43 - 1.09	600
4	0.80	17	0.50 - 1.59	800
5	0.80	6	0.34 - 2.17	150
6	1.01	16	0.35 - 3.20	400
7	1.00	8	0.40 - 2.10	150
8	0.96	10	0.40 - 2.10	85
9	0.95	16	0.43 - 2.50	225
10	0.80	16	0.62 - 2.79	350
11	1.20	10	0.90 - 2.01	300
12	0.95	17	0.64 - 1.74	350
13	0.91	9	0.50 - 1.30	300
14	0.72	17	0.24 - 2.06	400
15	0.90	7	0.61 - 1.65	70
16	0.84	7	0.60 - 1.60	100
17	0.8	12	0.40 - 1.10	600

#### Group Three Flocks

Flock	mean (mmol/litre)	number sampled	Range (mmol/litre)	Flock size
1	2.60	8	0.65 - 4.70	150

TABLE 4

The classification of flock mean serum 3-OH butyrate  
concentration and the occurrence of ovine pregnancy  
toxaemia in that flock

	Group 1	Group 2	Group 3
Flock mean 3-OH butyrate concentration (mmol/l)	0 - 0.7	0.8 - 1.6	1.7 - 3.0
Number of flocks	29	17	1
Number of flocks with clinical cases of ovine pregnancy toxaemia	0	2	1

A considerable range of individual results was encountered in the Group 2 flocks with some ewes falling into the category of severely-undernourished. Clinical cases of ovine pregnancy toxæmia were only encountered in the two flocks with individual ewe serum 3-OH butyrate concentrations above 3.0 mmol/litre and in the single Group 3 flock.

The occurrence of cases of ovine pregnancy toxæmia was a poor indicator of moderate underfeeding as only two of 17 moderately underfed flocks recognised clinical cases of ovine pregnancy toxæmia. Fifteen of the moderately-underfed flocks contained ewes which were severely-undernourished (serum 3-OH butyrate concentration greater than 1.6 mmol/l) but thirteen of these flocks did not experience cases of ovine pregnancy toxæmia. Retrospectively, following lambing, it was possible in some cases to associate the higher serum 3-OH butyrate concentrations with the presence of triplets in-utero.

### 5.2.3 CONDITION SCORE AND OVINE PREGNANCY TOXAEMIA

At the routine veterinary visit a mean flock body condition score of 2.5 or greater three to five weeks before lambing was considered to be acceptable for future performance targets. Twenty-two of the 47 flocks had a mean flock body condition score below 2.5, including the three flocks which subsequently experienced cases of ovine pregnancy toxæmia. The other 19 flocks with low mean flock body condition scores had no reported clinical cases of ovine pregnancy toxæmia.

Three to five weeks pre-lambing there was no significant relationship between the flock mean 3-OH butyrate concentration and the average body condition score of these ewes. All categories of energy status: adequately-fed, moderately-underfed and severely-underfed, occurred in



flocks with a group mean body condition score less than 2.5. These data indicate that a single assessment of ewe body condition alone three to five weeks prepartum is not an accurate determinant of energy status at that time.

#### **5.2.4 CONTROL OF OVINE PREGNANCY TOXAEMIA**

The incidence of ovine pregnancy toxaemia in the two Group 2 flocks was 1.5% (3/150) and 1.3% (6/400) with an incidence of 5.3% (8/150) for the Group 3 flock. In each of these flocks certain measures were adopted immediately after the routine advisory visit in an attempt to reduce the potential number of ovine pregnancy toxaemia cases. These measures included increasing the daily metabolisable energy allowance by approximately 3.0 MJ ME/head/day by feeding more concentrates and the provision of molasses licks. Despite the increased level of concentrate feeding cases of ovine pregnancy toxaemia occurred during the following seven to ten days. The implementation of such control measures may have reduced the incidence of ovine pregnancy toxaemia in these flocks but as not all the ewes in the flock were sampled it was not possible to determine the exact number of ewes which were at risk and, therefore, what influence control measures had.

#### **5.2.5 TREATMENT OF OVINE PREGNANCY TOXAEMIA CASES**

Treatment efficacy was difficult to quantify as there is no conclusive confirmatory test for the provisional clinical diagnosis of ovine pregnancy toxaemia. Treatment of suspected cases of ovine pregnancy toxaemia with concentrated oral electrolyte solution (Liquid Lectade(R), Smith Kline Beecham), intravenous glucose (Dextrose 40%) and dexamethasone (16 mg dexamethasone, Soludex(R), Mycofarm) did not improve their clinical condition and these ewes were euthanised.

### 5.2.6 LEVEL OF DAM NUTRITION AND PERINATAL DISEASE

There was no relationship between the level of dam nutrition, determined on one occasion three to five weeks prior to lambing, and the lamb perinatal mortality rate in those flocks classified as adequately fed and moderately underfed. The perinatal lamb mortality rate varied from 3% to 15% for adequately fed flocks. Only one severely underfed flock was encountered in this survey preventing further meaningful analysis of the data. In Tables 2 and 3 there is a large overlap of individual ewe 3-OH butyrate concentrations despite the group mean values being different. This range of dam nutrition within a flock, to some extent, may explain the lack of a significant relationship between level of dam nutrition and lamb perinatal mortality between flocks. There is, in addition, a large number of other managemental factors apart from dam nutritional status during late gestation which can significantly influence the perinatal lamb mortality rate.

### 5.2.7 PROTEIN STATUS

Protein status was determined in eight commercial flocks. The serum blood urea nitrogen concentration was considered indicative of short term rumen degradable protein intake and serum albumin concentration as an indicator of more long term protein status. While non-dietary influences on hepatic albumin synthesis such as Fasciola hepatica infection (Sykes, Coop and Rushton, 1980) can be important, faecal sampling of certain flocks in this study did not identify any infected flocks. One flock has a group mean blood urea nitrogen concentration below the normal range (2.6-6.6 mmol/l) although four of eight flocks had individual ewe blood urea nitrogen concentrations below normal. The normal range for serum albumin concentration is quoted as 24-35 g/l

(Doxey, 1983) and two of eight flocks had a group mean serum albumin concentration below this normal range.

In this survey, when the ewes were sampled three to five weeks prior to lambing, there was no significant correlation between the group mean serum albumin concentration and the blood urea nitrogen concentration.

On a within-flock basis there was no significant relationship between the serum albumin concentration and the body condition score of individual ewes. The small variation in serum albumin concentration (22 to 32 g/l) on a within-flock basis compared to the large variation in body condition score (1.5 to 4.0) may have contributed to the lack of such a relationship.

### **5.3 DISEASE INCIDENCE DURING LATE GESTATION**

#### **5.3.1 LISTERIOSIS**

Listeriosis was only encountered on those three farms which fed silage. On each of these three farms the meningo-encephalitic form of listeriosis was encountered. No septicaemic or abortion forms of listeriosis were identified. The incidence of listeriosis varied from 0.13 (1/650) to 3% (10/350). One flock encountered a 1.5% incidence of listeriosis one year but no cases the following year. In each instance silage analysis indicated adequate preservation properties with the pH below 4.5 and less than 10% nitrogen as ammonia-nitrogen. A wide silage clamp face and the use of a tractor fore-end loader rather than a block cutter to load silage were considered to be important factors in the aetiology of listeriosis on these farms.

### 5.3.2 VAGINAL PROLAPSE

The incidence of preparturient vaginal prolapse was studied on four farms. The results are presented in Table 5.

TABLE 5

The incidence of preparturient vaginal prolapse and lamb survival of these ewes in four flocks compared to control ewes

Farm	Total No. ewes	Vaginal Prolapse ewes	Ewe Mortality	Live lambs	Stillborn lambs	Total lambs	Still- born %
A	847	7 (0.8%)	0 (0%)	16	0	NR	0
B	347	20 (5.8%)	0 (0%)	20	20	615	3.3
C	344	9 (2.6%)	1 (11%)	10	6	645	0.9
D	474	9 (1.9%)	5 (55.6%)	9	11	844	1.3

NR Not recorded

The incidence of vaginal prolapse varied from 0.8 to 5.8% with a range of ewe mortality for ewes with vaginal prolapse from zero to five of nine cases (55.6%) on farm D. On three of the four farms studied the lamb stillbirth rate was greatly increased where the dam had a history of vaginal prolapse. Only on farm B is it likely that a high stillbirth rate due to previous vaginal prolapse would significantly contribute to the overall perinatal mortality rate of the flock.

In this field survey the importance of vaginal prolapse in relation to ewe and lamb mortality was difficult to determine for a number of reasons which relate primarily to management and not veterinary treatment. Firstly, the vaginal prolapse may have been present for a number of days with a variable degree of superficial trauma and infection before veterinary attention was called. Occasionally farmers

had attempted replacement unsuccessfully before veterinary assistance was sought. Secondly, in other instances vaginal prolapse could have been associated with incomplete cervical dilation in cases of abortion and this may have gone undetected. Each of these factors considerably influences the prognosis of the ewe and lambs. Once a vaginal prolapse has been replaced the ewe must be regularly observed for signs of first stage labour because certain methods of vaginal prolapse restraint, in particular a Buhner suture, prevent the completion of second stage labour.

In order to determine the influence of vaginal prolapse on the overall lamb perinatal mortality rate, the occurrence and practical management of vaginal prolapse was studied on one farm with direct veterinary supervision over a five year period. The annual incidence of preparturient vaginal prolapse was 0% (0/30), 3% (1/30), 0% (0/100), 2% (4/200) and 2.5% (6/250). Vaginal prolapse recurred during the subsequent pregnancy in two ewes. Dystocia resulting from a fibrous vulval band associated with the Buhner suture occurred in one ewe and an episiotomy was performed. No other dystocia problems were encountered with vaginal prolapse cases at parturition. While the number included in this survey is small (only eleven ewes), it was concluded that in flocks free of chlamydial abortion vaginal prolapse should not present significant problems provided such cases are treated promptly and correctly in the first instance.

In this study two ewes presented with cervico-vaginal prolapse for the first time during first stage labour; one dystocia was corrected by caesarian operation, the other by digital dilation of the cervix. In

the latter case, post-parturient uterine prolapse occurred. The uterus was replaced in the normal manner and the ewe progressed uneventually.

A large number of factors are thought to be implicated in the aetiology of preparturient vaginal prolapse and it is interesting to note in this study that a high incidence of vaginal prolapse (greater than 1%) was equally represented in adequately fed and moderately underfed flocks. A high incidence (greater than 3%) of vaginal prolapse on one farm in this survey was thought to be caused by the associated abortion of foetuses resulting from C. psittaci infection.

#### **5.4 WOODHOUSELEA SUFFOLK TRIAL**

##### **5.4.1 LAMB BIRTHWEIGHTS**

There was a large range of lamb birthweights from 1.8 to 7.3kg. Average lamb birthweights (kg) for singletons, twins and triplets were  $5.5 \pm 0.94$ ;  $4.4 \pm 0.88$  and  $3.45 \pm 0.85$  respectively.

##### **5.4.2 STILLBORN LAMBS**

The stillborn rate was 6.5% (23 of 374). The average birthweight of stillborn lambs was 3.8 kg. with a wide range of birthweights for stillborn lambs from 1.4 to 7.3 kg. The birthweights of stillborn lambs were uniformly distributed within this range with no evidence of a bimodal distribution. There was no significant difference between the mean birthweights of stillborn and living lambs ( $P > 0.05$ ).

#### **5.4.3 LAMB MORTALITY RATE**

Four lambs died within the first three days of life which represented a mortality rate of 0.8% (4/351). These lambs were of average birthweights (range 4.3 to 5.85kg).

#### **5.4.4 PLACENTAL WEIGHT**

Placentae were collected from approximately 60% (134 of 240) of lambings. There was a wide range of placental weights from 125 to 830g with a mean of 467g and standard deviation of 147g.

The placentae recovered from some multiple pregnancies had a distinct bilobed appearance and at the junction of the "lobes" the placenta was narrow and contained few sparse cotyledons. In such cases it was assumed that some degree of placental fusion had occurred. This area of fusion was relatively small and it was not possible to determine whether fusion of the blood supply to each foetus had occurred. In this situation where it was suspected that limited placental fusion had occurred the mean placental weight was calculated by dividing the total placental weight by the litter size. These data revealed a more consistent pattern to placental weights and have been used in subsequent analyses.

#### **5.4.5 PLACENTAL WEIGHT AND LAMB BIRTHWEIGHT**

There was no significant relationship between total litter placental weight and total litter lamb birthweight ( $P>0.05$ ).



#### **5.4.6 PLACENTAL WEIGHT AND STILLBIRTHS**

The small number of stillborn lambs, none of which was a singleton, prevented further investigations of placental function in relation to stillbirth in this particular flock.

Placental weights below 300g were associated with the birth of a viable lamb. It would appear from the data presented from this flock that low placental weight is not always a significant factor contributing to a high stillborn percentage or high perinatal mortality figures. The exemplary husbandry standards and level of stockmanship were considered major factors in the excellent results achieved in this flock.

#### **5.4.7 COTYLEDON MEASUREMENTS**

There was a wide range of placental cotyledon number from 31 to 106. The average number of cotyledons per placenta was 57.8 with a standard deviation of 21.5. Cotyledon size was very variable both within and between placentae with a range from 5.0 to 25.0mm in diameter. Total cotyledonary area may have been a more useful indicator of placental function but was not calculated as this estimation would necessitate detailed dissection of the placenta. It is likely that such a measure would have little application as a field technique in the measurement of placental function.

#### **5.4.8 PLACENTAL WEIGHT AND COTYLEDON NUMBER**

There was no significant relationship between placental weight and cotyledon number ( $P > 0.05$ ). There was the tendency for a heavier placenta to have an increased number of cotyledons because in such situations limited fusion of two placentae was thought to have occurred.

Following this study at Woodhouselea the assessment of placental function by counting the number of cotyledons was discontinued for the following reasons:

- i) the procedure was time-consuming and necessitated post-mortem room facilities to wash and dissect the placenta to permit accurate counting;
- ii) the risk of zoonosis exists from handling placental material from flocks with a history of chlamydial and other causes of abortion;
- iii) the variable size of cotyledons suggested that cotyledon surface area was perhaps a more important factor than actual number and such a measuring procedure would have little field application;
- iv) there was no significant correlation between cotyledon number and the other variables studied such as lamb birthweight and lamb viability.
- v) the large variation in placental weights associated with similar litter birthweights may indicate that other factors such as placental perfusion may be important in the determination of litter birthweight.

## 5.5 COMMERCIAL FLOCKS SURVEY

### 5.5.1 PLACENTAL WEIGHT AND STILLBIRTH

The relationship between placental weight and stillbirth was investigated on one commercial farm. The average litter placental weights recorded throughout the lambing period on one farm are presented in Table 6.

TABLE 6

Average litter placental weights recorded on four separate occasions during the lambing period

	Placental weight (g)	Range (g)	Number
Day 1	758 $\pm$ 290	330-1100	24
5	665 $\pm$ 256	310-1190	89
8	679 $\pm$ 223	290-1190	25
11	588 $\pm$ 273	260-1350	38

There was a large spread of placental weights as indicated by the large standard deviation values similar to the findings at Woodhouselea.

Placental weights as low as 260g were capable of supporting a viable foetus to full term. The very low number of stillborn lambs on this farm prevented further analysis between stillbirth and placental weight although it was possible to postulate that low placental weight did not necessarily predispose to physiological or metabolic problems at parturition resulting in a failure to adapt to the extrauterine environment resulting in death of the neonate.

The large range of placental weights found in this study (260-1350g) and the collection of only one placenta from certain twin pregnancies may

suggest that placental fusion may occur to a limited degree in some litters.

It was not possible to compare placental weights on a dry matter (DM) basis. However, as all free fluid was removed before the placentae were sealed in watertight plastic bags and the placentae weighed that same day, variation in the dry matter content was considered to be small relative to actual placental weight.

#### **5.5.2 ABORTION**

A provisional diagnosis of the cause of abortion was made based on the flock history, epidemiological findings and clinical examination of the ewe and aborted material. The diagnosis was confirmed by the laboratory methods outlined earlier in the materials and methods section.

#### **5.5.3 BORDER DISEASE**

Clinical signs of cerebellar disease were observed in three newborn lambs on one farm but no coat change due to proliferation of guard hairs could be appreciated. Investigation revealed seronegative, virus negative blood samples for border disease virus from these lambs. Clinical signs suggestive of border disease were encountered on two other farms in this series involving only two lambs on each farm. Diagnosis was confirmed by demonstrating typical changes of border disease on histopathological examination of brain tissue.

#### **5.5.4 TOXOPLASMA GONDII**

The majority of farms in this survey fed monensin sodium at a minimum inclusion rate of 10mg/head/day during the last 70 days of gestation. Sporadic cases of T. gondii infection were suspected on several farms.

The birth of one normal lamb and one mummified foetus was the usual presentation of toxoplasmosis. An abortion problem was only encountered on one farm which did not use medicated feedstuffs. In this instance the abortion rate caused by toxoplasmosis was 14%. Collection of serum samples from colostrum-deprived lambs to investigate the prevalence of foetal infection with T. gondii was not carried out on this farm. It was, therefore, not possible to determine whether, as well as mummification, foetal infection by T. gondii affected either the stillbirth rate or perinatal mortality rate.

The barren ewe rate was in the range from 2% to 4% in the majority of flocks in this survey. In three flocks with a barren ewe rate greater than 4% serological examination of barren ewes, when they would be expected to be three to four months pregnant, failed to reveal evidence of recent T. gondii infection.

#### **5.5.5 CHLAMYDIA PSITTACI**

The prevalence of chlamydial abortion was investigated in control groups on 10 farms. The effect of antibiotic administration three weeks before the expected lambing date on the rate of abortion was also studied. The results are presented in Table 7.

The overall incidence of chlamydial abortion per farm varied from zero to 13.0% (Farm A). There was also considerable variation in the incidence of chlamydial abortion between different years on the same farm. The results of the second year of this study are presented in Table 8. Overall, the administration of a single antibiotic injection to pregnant ewes in flocks with endemic chlamydial abortion reduced the

incidence of abortion but this difference was not statistically significant ( $P>0.05$ ).

#### 5.5.6 PERINATAL LAMB MORTALITY RATE

In addition to the abortion rate the perinatal lamb mortality rate was also studied on two farms. The perinatal lamb mortality rate was 5.8%, 5.3% and 3.1%; 8.9%, 9.0% and 3.9% for the control, oxytetracycline-treated and tylosin-treated groups on farms L and D respectively. These differences were not statistically different ( $P>0.05$ ) and therefore the perinatal lamb mortality rate was not affected by treatment of the dam with a single antibiotic injection three weeks before the expected parturition date.

In the following year on farm L the perinatal lamb mortality rate was 1.1% in the two oxytetracycline treatment groups and 0.6% in the control group. The higher perinatal lamb mortality rate in the former lambing season was due to a severe colibacillosis problem which would not be influenced by prior treatment of the dam with antibiotics during late gestation.

#### 5.5.7 CHLAMYDIA PSITTACI AND STILLBIRTH RATE

The stillbirth rate and percentage of weakly lambs was investigated on four farms with a known history of chlamydial abortion (Table 9). There was a large variation in the stillbirth rate (from 1% to 15%) between farms in this study. There was no significant effect of prior antibiotic treatment of the dam during late gestation on the stillbirth rate. The large variation in the stillbirth rate between these four farms, which had similar chlamydial abortion rates, would suggest that

factors other than C. psittaci were responsible for the high stillbirth rate.

Overall there was a low abortion rate caused by C. psittaci infection in the flocks studied in this survey. While administration of an antibiotic three to four weeks prior to fullterm reduced the prevalence of chlamydial-induced abortion, the numbers involved were too small for statistical analysis. With such a low abortion rate due to C. psittaci the number of weakly lambs born as the result of chlamydial placentitis would be expected to be similarly low. This factor should be borne in mind when comparing the data for stillborn rate and perinatal lamb mortality rate between the control and treatment groups in Table 9. For example, for Corsehope Farm few chlamydial abortions were reported but a stillborn rate of 15% was reported in one of the treatment groups. Conversely, at Bankhouse few stillborn lambs were recorded from groups of sheep which had experienced chlamydial abortions.



TABLE 7

The effect of prophylactic antibiotic administration  
on the incidence of abortion caused by  
Chlamydia psittaci on 10 farms (Year 1)

Farm Code	Control			Group E			Group T		
	EAE	Total	Group size	EAE	Total	Group size	EAE	Total	Group size
F	2	3	180	0	3	180	0	2	180
M	2	2	94	4	4	129	1	1	102
L	8	11	150	2	3	150	6	7	150
A	21	26	200	9	9	200	6	6	200
D	2	5	100	0	0	100	0	0	100
P	1	2	110	1	3	110	1	2	110
W	6	7	130	0	0	130	1	3	130
B	3	4	200	3	4	200	2	5	200
I	0	0	18	1	1	18	1	1	18
E	0	1	60	0	2	60	0	0	60
Total	45	61	1242	20	29	1277	18	27	1250

E - Engemycin 10%DD (10% oxytetracycline)

T - Tylan 200 (200mg/ml Tylosin)

Treatments administered three weeks before the expected lambing date.

TABLE 8

The effect of prophylactic antibiotic administration on the incidence of abortion caused by Chlamydia psittaci on five farms (Year 2)

Farm Code	Control			10% Oxytetracycline			20% Oxytetracycline		
	EAE	Group size	(%)	EAE	Group size	(%)	EAE	Group size	(%)
M	1	60	1.3	4	10	4.0	2	100	2.0
D	2	102	2.0	10	114	8.8	2	85	2.4
L	5	137	3.6	4	115	3.5	0	83	0.0
T	2	217	0.9	6	140	4.2	4	250	1.6
W	1	79	1.3	3	74	4.1	0	83	0.0

TABLE 9

The effect of prior administration of antibiotic to the dam  
on the birth of normal, weakly and stillborn lambs  
on four farms with a history of Chlamydia psittaci abortion

TREATMENT	CONTROL	ENGEMYCIN	TERRAMYCIN
<u>Easter Middleton</u>			
Normal	187 (92.0%)	196 (86.3%)	142 (84%)
Weakly	1 (0.5%)	5 (2.2%)	3 (1.8%)
Stillborn	15 (7.5%)	26 (11.5%)	24 (14.2%)
Total lambs	203	227	169
Abortion	2	10	2
<u>Bankhouse</u>			
Normal	267 (97.8%)	225 (98.2%)	162 (98.0%)
Weakly	3 (1.1%)	2 (0.9%)	2 (1.2%)
Stillborn	3 (1.1%)	2 (0.9%)	1 (0.8%)
Total lambs	273	229	165
Abortion	5	4	0
<u>Torcraik</u>			
Normal	397 (91.5%)	270 (96.4%)	468 (93.6%)
Weakly	7 (1.6%)	5 (1.8%)	8 (1.6%)
Stillborn	39 (6.9%)	5 (1.8%)	24 (4.8%)
Total lambs	434	280	500
Abortion	2	6	4
<u>Corsehope</u>			
Normal	151 (95.6%)	124 (84.3%)	154 (92.8%)
Weakly	0 (0%)	1 (0.7%)	2 (1.2%)
Stillborn	7 (4.4%)	22 (15.0%)	10 (6.0%)
Total lambs	158	147	166
Abortion	1	3	0

### 5.5.8 PREMATURITY AND STILLBIRTHS

The chronological occurrence of stillborn lambs during the lambing period was studied on three farms (Table 10).

TABLE 10

Chronological occurrence of stillborn lambs during the lambing period on three farms.

Week of lambing period	Farm C	EM	M
-1	13 (38.2%)	30 (50.8%)	11 (21.6%)
1	14 (41.2%)	9 (15.5%)	11 (21.6%)
2	6 (17.6%)	6 (10.2%)	22 (43.2%)
3	1 (3.0%)	9 (15.5%)	4 (7.8%)
4	0	2 (3.4%)	3 (5.9%)
5	0	0	0
6	0	3 (5.1%)	0
Total number stillborn lambs	34	59	51
Total number abortions	4	14	12
Number aborted ewes previously treated with antibiotics	3	12	10

On each farm a high percentage of stillbirths occurred during the week before lambing was due to commence which may indicate that prematurity is an important factor in some stillbirths. Few stillbirths occurred after the third week of the lambing period.

On all four farms the prevalence of abortions caused by C. psittaci placentitis may have resulted in an increased lamb stillbirth rate. No examinations were made of the stillborn lambs for chlamydial infection so it is not possible to comment further on this possible cause of stillbirth.

#### 5.5.9 CAMPYLOBACTER SPP

Campylobacter foetus foetus was not implicated as a cause of abortion in any of the abortion investigations.

#### 5.5.10 SALMONELLA SPP

Salmonella montevideo was associated with outbreaks of abortion on two farms in this survey. Affected ewes had clinical signs suggestive of a septicaemia and aborted autolytic fetuses one to four weeks prior to the expected lambing date. Following the brief abortion storm caused by S. montevideo, the subsequent lambing period progressed with no increase in the perinatal lamb mortality rate compared to the flock performance in previous years. Both farms were in the same geographical area as another six flocks which experienced abortions caused by S. montevideo abortion. In each flock faecal contamination of the sheep feeding area by gulls was considered to be the source of infection.

Salmonella derby was the cause of late abortions on one farm where the farmer had previously treated two-thirds of the flock with an oxytetracycline preparation in an attempt to control chlamydial abortion. Seven ewes aborted in a two day period (Table 11). Three sets of abortion material were sampled and yielded a profuse pure growth of S. derby from foetal stomach contents. A single injection of long-acting oxytetracycline was administered to all ewes at a dose rate of

16mg/kg intramuscularly. On the day of treatment and the following day a total of ten more abortions occurred. Thereafter, only one more abortion occurred. Aborting ewes were pyrexemic, completely anorexic, severely toxemic and experienced a high mortality rate. Lambs born to affected ewes were dead and in varying degrees of autolysis. Lamb perinatal mortality for the remainder of the flock was not dissimilar to previous years' figures. No bacteriological examinations of living lambs were undertaken and, therefore, the importance of S. derby infection in other neonatal disease situations could not be determined.

TABLE 11

The occurrence of Salmonella derby abortion in a 600 ewe flock in relation to antibiotic treatment

	Number of abortions
17.3.91	2
18.3.91	5
19.3.91 )	
Antibiotic treatment )	10
20.3.91 )	
21.3.91	1
22.3.91	
and later	0

#### 5.5.11 LEPTOSPIRA SPP

There was no clinical evidence of leptospirosis in any of the flocks in this study.

#### 5.5.12 CONGENITAL ABNORMALITIES

Entropion was the most commonly observed congenital abnormality with flock incidence figures ranging between 0.5-5%. The incidence of entropion was most prevalent in the offspring of Border Leicester rams

and within this breed certain rams sired offspring with an unacceptably high (greater than 25%) incidence of entropion. This congenital abnormality was easily corrected by everting the lower eyelid using a single subcutaneous injection of 5% oxytetracycline solution into the area overlying the zygomatic arch.

In one flock a five year study involving over 2,000 lambs revealed that only one death was associated with a congenital abnormality; that of atresia ani which could not be repaired surgically.

From the other flocks in this study, sporadic cases of congenital cardiac abnormalities such as ventricular septal defect and patent ductus arteriosus were identified at necropsy. However, such random submissions prevent a detailed analysis of the true incidence of such congenital abnormalities.

#### **5.5.13 MASTITIS**

Mastitis was an uncommon cause of either reduction or complete absence of colostrum accumulation because of the culling policy practised on these farms. The majority of flocks in the survey used intramammary antibiotic therapy at weaning, usually during July or August, and all ewes with mastitic glands at the pre-breeding soundness examination in October were culled. When one mastitic gland was discovered at lambing time the ewe was left to rear only one lamb or, in exceptional circumstances, a ewe could rear twin lambs on only one functional gland.

One flock which did not use an intramammary preparation at weaning experienced a mastitis incidence of 4.3% (10 of 230) at lambing time. In each case the ewe reared only one lamb.



#### 5.5.14 CONDITION SCORING

Condition scoring as a flock management aid was used to a variable degree by all the farmers in this survey. Improved nutrition prior to mating (flushing) ensured that all ewes were in a condition score greater than 3.0 at mating and condition scores of 4.0 were not uncommon. Some flocks were monitored at four to six week intervals. However, following mating the majority of flocks were not condition scored again until housing or at the time of vaccination against the clostridial diseases which takes place four to six weeks prior to lambing.

Farmers employed condition scoring to give an overall impression of ewe body condition scores. None of the farmers in this study actually recorded individual ewe condition scoring to check at a later date. The amount of useful information that could be obtained from such a haphazard assessment of condition scores is, therefore, likely to be strictly limited and restricted to determining marked changes in condition scores. For this reason no record was taken of the farmers' opinion of ewe condition. When questioned, the majority of farmers believed that poor ewe body condition scores found at vaccination time could be offset by the improved nutrition during the last six weeks of pregnancy.

There was no increased incidence of vaginal prolapse in those flocks with condition scores greater than 3.0 six weeks prior to lambing compared to flocks with condition scores less than 3.0.

#### 5.5.15 CEREBROSPINAL FLUID SAMPLES

Cerebrospinal fluid samples were collected from 20 lambs with a bacterial infection of the central nervous system. The results of cerebrospinal fluid analyses are presented in Table 12. Samples were also collected from ten lambs with a widespread pyaemia evident as liver abscesses and fibrinous polyarthrititis. The lambs were aged between one day and eight weeks. There was no evidence of haemorrhage or xanthochromia in any of the cerebrospinal fluid samples.

Lumbar cerebrospinal fluid samples from lambs with bacterial infections of the central nervous system showed a significant ( $P < 0.05$ ) increase in total protein concentration. A significant increase in total white blood cell count ( $P < 0.05$ ) was present in the bacterial meningitis group. While the cerebrospinal fluid neutrophil percentage was increased in animals with bacterial infections of the central nervous system, because of the large standard deviation value, there was no significant departure from normal.

Gross examination of cerebrospinal fluid collected from six stillborn lambs did not display any evidence of haemorrhage or xanthochromia. It was not always possible to collect stillborn lambs immediately following parturition from the farms participating in this study. If more than six hours had elapsed between the death of the lamb and cerebrospinal fluid collection, the cerebrospinal fluid sample was often viscous and more difficult than usual to collect. It was not possible to ascertain whether this sampling difficulty was due to the reduced cerebrospinal fluid volume, reduced pressure following death or from increased cerebrospinal fluid viscosity caused by the leakage of blood proteins into the subarachnoid space. This difficulty with cerebrospinal fluid

collection from recently dead lambs explains the relatively small number of useful cerebrospinal fluid samples that could be collected from dystocia cases and perinatal deaths in this study.

TABLE 12

Gross appearance of cisternal and lumbar cerebrospinal fluid from lambs with a central nervous system lesion

Lesion	Meningitis	Epidural	Abscess	Vertebral Body	Abscess
Site	Lumbar	Cisternal	Lumbar	Cisternal	Lumbar
Number	7	5	5	8	8
Specific gravity	1.014 $\pm 0.0054$	ND	ND	1.011 $\pm 0.002$	1.013 $\pm 0.001$
Protein (g/l)	2.19a $\pm 1.94$	0.45b $\pm 0.28$	2.92a $\pm 1.57$	0.56b $\pm 0.42$	2.23a $\pm 0.99$
Total WBC ( $\times 10^9/l$ )	3.99a $\pm 6.0$	0.08b $\pm 0.04$	0.22b $\pm 0.15$	0.076b $\pm 0.11$	0.44b $\pm 0.56$
Neutrophil (%)	75.1 $\pm 29.3$	occ.	65.2 $\pm 32.1$	occ.	49.3 $\pm 32.8$
Lymphocyte (%)	14.6 $\pm 15.4$		13.2 $\pm 24.5$		10.8 $\pm 10.5$
Histiocyte (%)	10.3 $\pm 14.7$	occ.	20.6 $\pm 33.4$	occ.	35.3 $\pm 37.0$

ND: not done  
occ.: occasional

Normal Values: specific gravity <1.010  
protein concentration <0.3g/l  
total WBC count <0.012 $\times 10^9/l$   
lymphocytes >70%  
neutrophils <30%

Values with different superscripts are significantly different ( $P < 0.05$ ).

#### **5.5.16 DYSTOCIA**

The incidence of dystocia which required veterinary assistance was monitored in thirty flocks over a two year period. This figure varied from zero to 3% of ewes in the flock. This value was considered to reflect the attitude of the attending shepherd rather than the true incidence of serious dystocia. It was not possible to determine the mortality rate as a consequence of excessive interference of a dystocia. Relative foetal oversize as a cause of perinatal mortality was encountered in only one flock in this survey on this farm. Half-bred ewe lambs had been mated with a Suffolk ram which resulted in a 20% severe dystocia incidence of which 50% necessitated a caesarian operation. With this exception, foetal oversize was uncommon and there was no significant relationship between the incidence of dystocia which required veterinary assistance and the level of ewe nutrition defined as adequately-fed or moderately-underfed during late gestation. Again, this relationship would be considerably influenced by the attitude of the shepherd to veterinary assistance of dystocia cases.

#### **5.5.17 PROPHYLACTIC ANTIBIOTIC ADMINISTRATION TO LAMBS**

There was a wide range of control measures for the control of watery mouth and associated coliform enteritis. Only one of the 20 lowground flocks studied in detail did not use oral antibiotics within the first 30 minutes of the lamb's life. This farm had exemplary hygiene standards. On this farm the lambing pens had a concrete base which allowed thorough cleaning and disinfection between each sheep and fresh straw bedding was used each time. In addition, cow colostrum at a rate of 50mls/kg birthweight was administered by stomach tube within the first two hours of life to lambs when the ewe was suspected of having insufficient colostrum.

The antibiotics used for routine oral antibiotic administration to all multiple births within the first 30 minutes of life were:

neomycin + streptomycin (Oroject N/S(R))	9 Farms
amoxycillin (Clamoxyl(R))	9 Farms
furazolidone (Neftin(R))	2 Farms

#### 5.5.18 WATERY MOUTH

A study was undertaken on eight farms to investigate the incidence of watery mouth and to determine whether prophylactic oral antibiotics were necessary to prevent this condition. This study involved the use of metoclopramide which was administered to lambs within the first 30 minutes of life at a dose rate of 1.0mg/kg bodyweight. The results are presented in Table 13.

TABLE 13

Incidence of watery mouth in metoclopramide treated and control lambs in eight flocks

Flock	Metoclopramide-treated			Control Group		
	Number treated	Watery mouth	Died	Number treated	Watery mouth	Died
WL	26	0 0%	0 0%	25	0 0%	0 0%
A	363	6 1.6%	0 0%	65	28 43.0%	4 6.1%
O	132	23 17.4%	2 1.6%	162	24 14.8%	6 3.7%
C	234	4 1.7%	2 0.4%	325	8 2.4%	1 0.3%
B	173	19 10.9%	1 0.6%	179	53 29.6%	0 0%
F	50	0 0%	0 0%	50	5 10%	0 0%
E	100	0 0%	0 0%	100	8 8%	0 0%
EB	20	0 0%	0 0%	20	0 0%	0 0%

The incidence of watery mouth varied considerably in the control group from 0 to 43%. Two farms F and E reverted to prophylactic antibiotics as soon as watery mouth cases occurred in the control group. Three farms recorded a low incidence of watery mouth in both the control and metoclopramide treatment groups. One flock recorded a marginally higher incidence of watery mouth in the metoclopramide treated group while prophylactic administration of metoclopramide markedly reduced the incidence of watery mouth on two farms. Farms A and B discontinued the placebo treatments when the incidence of watery mouth reached over 40% and 30% respectively. On each farm the oral administration of

amoxycillin within the first 30 minutes of life to the later born lambs resulted in an incidence of watery mouth below 2%.

#### 5.5.19 INCIDENCE OF BACTERIAL INFECTIONS ON 20 FARMS

##### RESULTING FROM BACTERAEMIA IN THE NEONATAL PERIOD

In this study cases of joint-ill, meningitis, spinal abscess and endocarditis were considered to arise from a bacteraemia in the neonatal period. Such a bacteraemia was considered to result from either omphalophlebitis or entero-invasion in association with an a- or hypogammaglobulinaemic state. The incidence of bacterial infections was arbitrarily divided into three categories:

low, less than 1%, moderate 1-3%, or high, greater than 3%.

The results are presented in Table 14.

**TABLE 14**

Incidence of bacterial infections in young lambs  
on 20 farms

	low	moderate	high
incidence	less than 1%	1-3%	greater than 3%
number of farms	2	15	3

Joint-ill was the most common bacterial infection observed with only a small number of meningitis cases and spinal cord lesions recorded.

Three of twenty farms (15%) experienced a high incidence of bacterial infections. In each of these farms poor hygiene in the lambing shed and failure to immerse the whole umbilicus in strong iodine BP at birth and again four hours later were identified as important contributing factors. Dirty bedding also resulted in faecal contamination of the



ewe's fleece. The fleece contamination was often made worse by the ewe's natural pawing behaviour during first stage labour and the passage of large volumes of allantoic fluid. The teat-searching behaviour of the newborn lamb often included sucking contaminated wool before eventually finding the teat. Entero-invasion following the ingestion of E. coli before the absorption of passively-derived immunoglobulins was considered an important factor in the development of joint-ill lesions on these farms. Investigations of serology samples and bacteriology of joint aspirates for Epysipelas spp. proved negative. Serum sample analysis for immunoglobulin concentration in affected lambs was not undertaken. Only two farms of twenty farms (10%) experienced an acceptable low incidence of less than 1% neonatal bacterial infections.

#### 5.5.20 ADVERSE VACCINE REACTION

All sheep in this study were vaccinated annually against clostridial disease and the majority of farms used a combined clostridial and pasteurella vaccine (Heptavac P (R), Hoechst) administered within one month of the anticipated lambing date. The day following vaccination six of thirty farms reported that some ewes were dull, slow to move and reluctant to come to the feed troughs. Three farms reported that the ewes improved the following day and no adverse effects were noted (two days after vaccination). The remaining three farms reported a 2-4% incidence of inappetance amongst ewes two days after vaccination. While these ewes would not eat hay or concentrates, on two farms these ewes were turned outside and were later observed grazing.

Symptomatic treatment of these ewes consisted of oral fluid therapy b.i.d. (diluted Liquid Lectade), multivitamin injections (Parentrovite(R), Beecham Animal Health) and dexamethasone (Voren(R),

Boehringer). Blood samples collected at this stage from six ewes revealed serum 3-OH butyrate concentrations greater than 5.0mmol/litre, but the clinical signs were not consistent with a diagnosis of primary ovine pregnancy toxemia as some of the ewes remained bright and alert and were difficult to catch.

Five ewes produced small, premature lambs approximately seven to ten days after vaccination. All of these lambs died despite intensive supportive therapy. The remaining ewes which grazed, carried their lambs to full term and produced normal birthweight lambs. One of these ewes lambed triplets and nursed the three lambs successfully. These clinical findings are not consistent with a diagnosis of ovine pregnancy toxemia despite the elevated serum 3-OH butyrate concentrations. Exhaustive investigations failed to reveal any possible cause of this clinical condition other than adverse vaccine reaction.

#### 5.5.21 COW COLOSTRUM

Eight of thirty farms in this study used bovine colostrum to supplement triplet or weakly lambs. Despite the large numbers of lambs receiving bovine colostrum no adverse reaction was noted. Profound anaemia (packed cell volume less than 0.10 l/l) was investigated on one farm involving three, two to three week-old lambs. Laboratory investigation failed to demonstrate any haemolysis caused by reaction between the suspected bovine colostrum with the lamb red blood cells.

Three farms used colostrum substitutes and the farmers generally thought that the product (Osmond's Ewe Colostrum Supplement) was useful although on one farm an unacceptable incidence of watery mouth occurred despite the routine use of this colostrum supplement.

## 5.6 STUDIES AT WEST LATCH

### 5.6.1 PERINATAL MORTALITY

During a five year period all causes of lamb losses were investigated on an intensively-managed lowground flock. The results are presented in Table 15.

**TABLE 15**

A five year study of perinatal mortality  
in an intensively managed lowground flock

	1987	1988	1989	1990	1991
Total number lambs born	52	190	370	420	460
Total number lamb deaths	1	6	11	8	16
Prematurity	0	0	0	0	10
Stillborn	1	2	3	5	4
Intact amnion	0	2	1	0	0
Lain on	0	0	2	0	0
Congenital abnormality	0	0	1	0	0
Infectious disease	0	2	4	3	2

Perinatal mortality was relatively low in this flock with no single cause of such losses except for 1991 when a problem with premature lambs was encountered.

### 5.6.2 PREMATUREITY AS A CAUSE OF PERINATAL MORTALITY

Prematurity was defined as those lambs born between 140 and 147 days of gestation. In addition to gestation length, prematurity could be identified by small birthweight, short coat length and failure of the lamb to adapt to the extra-uterine environment. These lambs also had poor co-ordination and skeletal muscle function. Failure of these lambs

to find the ewe's teat and suck necessitated feeding colostrum via a stomach tube. Retention of meconium was a common problem in these lambs and abomasal distension was frequently observed due to poor abomasal function. Despite intensive supportive therapy and nursing, all of these premature lambs died. Post mortem examination revealed poor inflation of the lungs and agonal abomasal distension.

### **5.6.3 DYSTOCIA**

A five year study in this intensively-managed flock, involving a total of over 1,000 ewes, showed only one lamb death directly attributable to dystocia. Five caesarian operations were performed to correct a dystocia during this period.

### **5.6.4 MATERNAL BEHAVIOUR**

A study of maternal behaviour immediately following parturition was undertaken over the four year period 1988-1991. The major problem associated with maternal behaviour was the rejection of one lamb by those gimmers which had given birth to two or more lambs. This incidence varied between 6-10% per annum. Such rejection behaviour became apparent two to four hours after parturition. The dam would be aggressive towards the lamb, initially nudging it away, but then vigorously head butting the lamb and moving away to prevent the lamb sucking. This behaviour was only observed in one ewe representing an overall incidence of 0.1% in mature sheep.

The lack of mothering instinct observed in gimmers was not related to dam body condition score as all body condition scores were greater than 2.5. A brief period of recumbency following parturition and failure by the dam to lick the lambs dry immediately was considered a major cause

of this problem. Recumbency was often the result of prolonged first stage labour, dystocia or during the expulsion of the placentae (third stage labour). "Stealing" by other sheep in the group was another factor which resulted in a poor dam/offspring bonding. To reduce "stealing" and mismothering the dam and offspring were individually penned immediately following parturition.

There was no relationship between mean flock body condition scores or the level of nutrition three to five weeks prior to lambing and the reported incidence of poor maternal instinct. Problems of lamb rejection were only recorded with foster lambs.

#### **5.6.5 BACTERAEMIA/SEPTICAEMIA**

A five year study involving over 2000 lambs was undertaken on this farm to determine the lamb mortality rate resulting from bacteraemic/septicaemic conditions extending either from omphalophlebitis or enteroinvasion. The routine procedure following lambing on this farm was that the umbilical cord was fully immersed in strong iodine BP within the first 30 minutes of birth and again four and eight hours later. If lambs had not sucked by two hours old they were stomach tubed with colostrum. All dead lambs up to six months of age were subject to a post motem examination. One lamb (0.05%) aged three weeks presented with pelvic limb paresis associated with an epidural abscess at T7. Two small 0.5cm abscesses were present in the liver parenchyma. This was the only disease incident resulting from an umbilical infection. No cases of joint-ill, meningitis or vegetative endocarditis were observed. No prophylactic antibiotic preparations were administered on this farm.

## 5.7 WOODHOUSELEA GREYFACE TRIAL

### 5.7.1 DIET

The ewes at Woodhouselea were divided into eight groups of 30 ewes to investigate dietary influences on ewe and lamb performance. Comparisons were made between brewer's grains and silages which had been conserved using various additives. Full details are presented in the Materials and Methods sections.

There was no significant effect of any of the diets on lamb birthweight, ewe weight loss or blood metabolite concentrations and, therefore, all the groups have been combined for further analysis.

### 5.7.2 ACCURACY OF REAL TIME ULTRASOUND SCANNING

TABLE 16

Accuracy of real time ultrasound scanning  
in the Greyface flock

Number of lambs	Predicted Number	Actual Number	Accuracy
Barren	0	1	
Singleton	0	7	
Twins	230	184	78%
Triplets	0	38	

The ewes had been selected from a flock of over 600 on the basis that they were twin-bearing but the accuracy of the real time ultrasound scanning in predicting twin pregnancies in this flock was 78% (Table 16). The inclusion of approximately 15% of the ewes as triplet-bearing, however, more closely resembles typical litter size in a lowground flock.

### 5.7.3 DYSTOCIA

There was no evidence that absolute foetal oversize was a cause of dystocia in this flock. However, care must be exercised when analysing these data as these ewes had been scanned for twins and only seven singleton-bearing ewes were included (Table 16).

Three of seven singleton lambs were stillborn. The birthweights of these lambs, 5.95, 6.4 and 4.8 kg, are within the normal range for progeny of Greyface ewes and, therefore, absolute foetal oversize as such should not have resulted in stillbirth. In addition, the assistance given to these ewes resulted in an uneventful delivery of the lamb and veterinary attention was not necessary. Failure to detect the beginning of second stage labour caused by the foetus not entering the maternal pelvis could have been an important contributing factor to such stillbirths but this could not be determined.

The causes of dystocia in the Woodhouselea Greyface flock are presented in Table 17. Anterior presentation with shoulder flexion of one or both forelegs was the most common reason for assistance accounting for almost one half of assisted births. None of the dystocia cases required veterinary assistance.



TABLE 17

Causes of dystocia in a lowground Greyface flock

Normal anterior presentation	7
Anterior presentation, one foreleg shoulder flexion	35
Anterior presentation, both forelegs shoulder flexion	11
Anterior presentation, lateral deviation of head	8
Posterior presentation	4
Posterior presentation, both hind limbs flexed	6
Simultaneous presentation	1
Total number of assisted births	72

The number of lambs in multiple litters which presented with malpresentation, malposition and/or malposture are presented in Table 18. In 92% of dystocia cases involving multiple litters only one lamb in the litter had an abnormality which resulted in the dystocia. The overall dystocia rate was 14% (72/495) caused by relatively simple malpresentations and malpostures as outlined in Table 17.

TABLE 18

Number of lambs in multiple litters with abnormal presentation, position or postural abnormality at birth

Birth	Number	Percentage
One lamb only	66/72	91.7%
Both lambs	5/72	6.9%
All three lambs	1/72	1.4%

#### 5.7.4 STILLBIRTHS

Of the 22 stillbirths recorded representing 4.4% of total lambs born, nine were associated with dystocia (44%). However, this number of stillbirths was too small for statistical analysis.

There was no difference in the nutritional status during late gestation of those ewes which produced stillborn lambs compared to those ewes which produced live lambs (Table 19).

**TABLE 19**

Nutritional status during late gestation of dams  
which produced stillborn or live lambs

Category	Stillborn lambs	Live lambs
Adequately fed	14	163
Moderately underfed	1	36
Severely underfed	3	22
Total	18	221

#### 5.7.5 DIURNAL PATTERN OF PARTURITIONS

The percentage number of ewes lambing in each two hour period throughout the day is presented in Table 20. There was no identifiable diurnal peak period at which parturitions occurred.

TABLE 20

Percentage of ewes lambing in each  
two hour period throughout the day

Time (Hours)	Percentage ewes lambing	Number
00.05 - 02.00	6.0	13
02.05 - 04.00	6.9	15
04.05 - 06.00	6.9	15
06.05 - 08.00	12.5	27
08.05 - 10.00	7.9	17
10.05 - 12.00	7.9	17
12.05 - 14.00	9.7	21
14.05 - 16.00	8.3	18
16.05 - 18.00	7.4	16
18.05 - 20.00	10.2	22
20.05 - 22.00	9.7	21
22.05 - 24.00	6.5	14
Total	100	216

#### 5.7.6 PLACENTAL WEIGHTS

The placental weight measurements at Woodhouselea presented similar problems with analysis as in the previous studies. The placental weights were first divided into two groups comprising those litters where all placentae were collected after parturition and those births where only one placenta was collected. In the former group the average placental weight was 456g with a range from 290 to 600g and in the latter group was 639g with a range from 200 to 1120g.

It is possible that the low placental weights in the latter group represent only one of the two placentae associated with that multiple pregnancy. In the case of those placentae which weighed greater than 7-800g, fusion of adjacent placentae may have occurred. It was not possible to be certain that all placentae had been collected following the completion of third stage labour and, therefore, the possibility of placental fusion could not be investigated further. It would seem unlikely, however, that placental weights could vary from 200g to greater than 1000g and that placental weight could be the equivalent of approximately 25% of lamb birthweight.

#### **5.7.7 SUPPLEMENTARY FEEDING**

The number of newborn lambs which required supplementary feeding by stomach tube is presented in Table 21. This assistance with feeding was given to those lambs which were judged not to have sucked themselves by four hours old. Approximately 10% of all lambs were stomach tubed with dam colostrum and within this classification there was an increased prevalence of triplet lambs compared to twins. Supplementary feeding of triplet lambs with bovine colostrum was considered necessary for 58% (22/38) of all triplet births compared to only 18% (34/184) of twin births. Only 24% (9 of 38) of all triplet births did not receive any attention at lambing compared to 70% (136/184) of twin births.

TABLE 21

Incidence of multiple litters in which lambs required feeding  
by stomach tube with dam colostrum or bovine colostrum

	TWIN LITTERS	TRIPLLET LITTERS	TOTAL BIRTHS
Dam colostrum	14 (7.6%)	7 (18.4%)	21
Bovine colostrum	34 (18.5%)	22 (57.9%)	56
No treatment	136 (73.9%)	9 (23.7%)	145
Total	184 (100%)	38 (100%)	222

Where lambs were fed with dam colostrum by stomach tube the primary reason for assistance with feeding was weakly lambs and not insufficient accumulation of colostrum. Where supplementary feeding was necessary with bovine colostrum the primary indication was lack of colostrum accumulation. Insufficient colostrum accumulation was judged to be a problem in the majority of ewes that produced triplets.

The relationship between assisted delivery and the decision whether supplementary feeding of the lamb was necessary is presented in Table 22. There was no difference in the percentage number of lambs born assisted (16.2%) which required supplementary feeding compared to the percentage figure of lambs born unassisted (31%). From Table 22 it would appear that the birth of triplets rather than a dystocia increased the number of litters fed supplementary amounts of colostrum.

TABLE 22

The relationship between assisted delivery and requirement for supplementary feeding of lambs

	Lambs fed by stomach tube	Lambs with no supplementary feeding	Total
Presence of dystocia	27 (16.2%)	141 (83.8%)	168
Normal parturition	50 (31%)	104 (69%)	154

No laboratory tests were carried out to determine the presence of the anaemia factor in the bovine colostrum administered to this flock. Depsite the fact that 56 lambs received bovine colostrum no case of bovine colostrum-induced anaemia was noted. No case of lamb dysentery (Clostridium perfringens) type B infection was identified.

#### 5.7.8 FOSTERING LAMBS

Twenty-one lambs were fostered onto other ewes at Woodhouselea. The initial success rate was 81% (17/21) while the ewes were still confined in lambing pens. One lamb died due to crushing and three lambs were rejected by the ewe and subsequently reared as orphan lambs.

#### 5.7.9 INCIDENCE OF MASTITIS

Ten ewes at Woodhouselea (8%) had only one functioning mammary gland at lambing, the other mammary gland was hard and indurated, indicative of a previous chronic mastitis.

#### 5.7.10 GROSS MILK DEFICIENCY

Examination of the records at Woodhouselea identified seven ewes as grossly deficient in colostrum accumulation at lambing as judged by the attendant shepherd. Full records were available for six ewes. One ewe

had a serum 3-OH butyrate concentration within the range considered indicative of ovine pregnancy toxaemia (serum concentration 5.1 mmol/litre). This ewe and one other had lambed triplets. For the remaining four ewes there was no evidence of either dietary energy underfeeding or concurrent illness, particularly mastitis, which could account for the lack of colostrum accumulation.

#### **5.7.11 LITTER BIRTHWEIGHTS**

The influence of dietary energy adequacy during late gestation, as defined by serum 3-OH butyrate concentration, on litter birthweights is presented in Table 23. Based on data in the literature, acceptable minimum total litter birthweights of Greyface ewes were chosen as 8.0kg for twins and 9.5kg for triplets.

Only 15 twin litter birthweights were below 8.0kg representing 8.2% (15/184) of the total. Only two dams of these 15 litters were classified as severely underfed immediately prior to lambing. Eleven adequately-fed ewes produced total litter birthweights below 8.0kg. From a total of 358 twin lambs only 16 (4.5%) had a birthweight below 3.5kg. These results would indicate that dam nutrition was not an important factor in the majority of low twin birthweights in this particular study.

Nine of 38 (23%) triplet litter birthweights were below 9.5kg and of these nine ewes, six ewes were classified as severely underfed at lambing, five of these ewes for at least the preceeding four weeks. In the case of triplet pregnancies, severe dam undernutrition was associated with a reduced total litter birthweight. The total litter birthweight of those ewes classified as severely underfed at blood



sampling close to full-term was 7.1kg, approximately 2.4kg lighter than the average total litter birthweight of adequately-fed, triplet-bearing ewes. Too few animals were classified as severely underfed to permit statistical analysis.

In total, eleven of the 38 triplet-bearing ewes were classified as severely underfed at lambing. Five of them produced a total litter weight greater than 9.5kg.

TABLE 23

The number of litters less than 8.0kg for twins  
and 9.5kg for triplets in relation to dam nutritional status

	Litter size	
	Twins less than 8.0kg	Triplets less than 9.5kg
Dam nutritional status 4 weeks before lambing		
Adequately fed	11/184 (6.0%)	3/38 (7.9%)
Moderately underfed	4/184 (2.2%)	1/38 (2.6%)
Severely underfed	0/184 (0%)	5/38 (13.2%)
within one week of lambing		
Adequately fed	11/184 (6.0%)	3/38 (7.9%)
Moderately underfed	2/184 (1.1%)	0/38 (0%)
Severely underfed	2/184 (1.1%)	6/38 (15.8%)
Adequately fed	Serum 3-OH butyrate concentration 0.1-0.7mmol/l	
Moderately underfed	0.8-1.5mmol/l	
Severely underfed	greater than 1.6mmol/l	

Fifteen ewes which were classified as severely underfed within one week of lambing produced twin birthweights above 8.0kg. None of these ewes was classified as severely underfed four weeks before lambing but 4/15 (28%) were moderately underfed at that time. Severe undernutrition during only the last week or so of gestation did not result in twin litters below 8.0kg (Table 23). However, none of these ewes was severely underfed at the preceding sampling four weeks earlier and, therefore, had not been subjected to a prolonged period of severe undernutrition.

Factors other than the dam energy status, as defined by the serum 3-OH butyrate concentration, were responsible for the birth of 15 low twin birthweights which represented 8.2% of total twin births. No single factor was identified that could have accounted for these low litter birthweights.

It was concluded that energy status, defined by serum 3-OH butyrate concentration, was not an important factor in the production of low twin lamb birthweights. However, the period of dam undernutrition in this study was relatively short and few twin-bearing ewes were classified as moderately or severely underfed.

#### **5.7.12 EWE LIVEWEIGHT CHANGE**

A significant inverse correlation ( $P < 0.05$ ) was observed between the serum 3-OH butyrate concentration recorded within one week of the lambing date and the increase in ewe liveweight during the last four weeks of pregnancy. Severely underfed ewes gained only 2-4kg liveweight compared to 6-9kg gain for adequately-fed ewes. As the average litter size of severely underfed ewes was 2.2 to 2.3 compared with 2.0 to 2.1

for adequately-fed ewes, the larger litter size would be expected to increase total uterine weight and consequently ewe liveweight during late gestation. Therefore, ewes with larger litters would be expected to have higher total liveweight gain unless they had lost a greater amount of carcass weight. It is not possible to attribute all of the liveweight change to changes in ewe carcass weight as the content and weight of the gastrointestinal tract can vary considerably during late gestation.

It is expected that 75% of foetal growth occurs during the last six weeks of gestation (Russel, 1985) which may amount to 7.5-10kg. The small increase of 2-4kg during the last four weeks of pregnancy in the severely-underfed groups represents a loss in ewe bodyweight. Reduced gut fill and loss of actual carcass weight both contribute to the extra-uterine weight loss.

#### **5.7.13 CONDITION SCORE CHANGE**

While severely underfed ewes lost on average 0.3-0.5 condition score units during the last month of pregnancy, there was no significant correlation between condition score change and serum 3-OH butyrate concentration ( $P>0.05$ ) in all ewes.

It is interesting to note that in ewes with an increase in serum 3-OH butyrate concentration indicative of severe underfeeding, there was no corresponding reduction in serum albumin concentration. A reduction in serum albumin concentration may be expected in underfed sheep if the reduction in carcass weight consisted of catabolism of body protein as well as fat reserves.

The lack of a significant relationship between severe underfeeding and condition score change over the last four weeks of gestation, may in part be explained by 15 twin-bearing ewes which were classified as severely underfed but produced litter weights above 8.0kg and did not experience an excessive loss of body condition. No ready explanation could be found as to why these ewes had such elevated serum 3-OH butyrate concentrations indicative of severe undernutrition. These animals did not appear to experience any adverse effects on production in terms of reduced litter weights, colostrum accumulation at parturition or increased loss of body condition.

#### 5.7.14 TRIPLET LAMBS

No ewe was left to rear triplet lambs at Woodhouselea. The fate of 35 triplet lambs is detailed in Table 24.

TABLE 24

Fate of triplet lambs at Woodhouselea

Successfully fostered to another ewe	13
Transfer to lamb bar	13
Stillborn or died	9
Total	35

At best, only 13 lambs were used profitably. The value of orphan triplet lambs sold at the local market was less than £2 in April 1991. Any potential profit does not take into account labour, feeding and transport costs to the market.

Only 11 lambs which died within the first two days of life were available for post mortem examination. The results are presented in Table 25.

**TABLE 25**

The cause of death within the first  
three days of life at Woodhouselea

Cause of death	Number
Starvation	4
Trauma/asphyxiation	4
Diarrhoea	1
Torsion small intestine	1
No abnormality detected	1
Total	11

The average weight of lambs which died within the first day of life was not significantly different from that of living lambs ( $P>0.05$ ).

## **6.0 DISCUSSION**

### **6.1 PERINATAL MORTALITY**

The perinatal lamb mortality rate of between 3-5% on some of the farms in this study was very considerably less than the 15% or greater quoted by Whitelaw (1976), Eales et al. (1982a) and Barlow et al. (1987) but in general agreement with figures of 5% to 7% quoted in single flock studies (Safir, 1991; Trower, 1991). In addition, these farmers were able to maintain such a low perinatal lamb mortality rate each year. The low perinatal lamb mortality rates achieved by these farmers in this study are in good agreement with target values considered to be a realistic possibility by Hindson and Winter (1990) and Rook et al. (1990).

#### **6.1.2 STILLBIRTHS**

The low stillbirth rate in this series provides support for the supposition (Hindson and Winter, 1990) that strict supervision during the lambing period can result in a stillbirth rate as low as 1-2% of births. These findings indicate that a high stillbirth rate is the result of prolonged second stage labour caused by delay in correcting simple foetal malposition, malpresentation or malposture. If the dystocia involves the first lamb which is presented, evidence of dystocia such as discoloured subcutaneous oedema may be observed in this lamb at necropsy. In the event of a multiple birth the remaining lambs could be stillborn without such evidence of dystocia. These facts should be borne in mind when performing post mortem examinations of stillborn lambs. In this study passage of the placentae with the lambs only occurred if second stage labour had been delayed for about 24 hours.

### 6.1.3 LEVEL OF STOCKMANSHIP

It was not possible to quantify objectively the level of stockmanship on a particular farm as there are no recognised qualifications other than attendance at relevant Agricultural Training Board (ATB) courses. Similarly, the number of full-time attendants employed during the lambing period was difficult to determine as usually these people were variably involved with other livestock and arable duties. It was concluded that the maximum number of ewes that could be properly supervised was 125-150 per full-time attendant during the busy first two weeks of the lambing period when approximately 80% of ewes lambed. In this definition full-time work equals 12-16 hours per day, seven days per week.

The majority of farms in this study were selected for their high standard of husbandry. This selective approach was different to many previous field studies in that it attempted to investigate positive management practices and not obvious gross management deficiencies which are related to high perinatal lamb mortality rates.

This study concluded that strict flock supervision can contribute to low perinatal mortality rates. No support could be found for the statement that "lambs that die in the perinatal period reveal the importance of birth injury as a cause of perinatal loss" (Wilsmore, 1986). The conclusion reached by Wilsmore (1986) is unrepresentative of modern lowground sheep production because it investigated perinatal mortality of a Dorset flock lambing in the autumn. The flock had a lambing percentage of 183%, a barren rate of 21% and an extended lambing period of seven weeks. Such a protracted lambing period, coupled with abundant grass during late summer and autumn, would be expected to result in

excessive ewe body condition during mid pregnancy extending up to lambing time which could have resulted in the high incidence of reported birth injuries. In any flock with a high incidence of birth injuries the level of competence of the attending shepherd has to be seriously questioned.

In the national flock there is little support for a selection process based on lamb birthweight and maternal pelvic diameter (Rabalo Silva and Noakes, 1984) recommended by Wilsmore (1986) because in this present survey of 20 flocks representing 15,000 ewes dystocia was not an important factor contributing to lamb mortality.

By investigating flocks with high levels of production in this survey, realistic performance targets could be set within the financial constraints of commercial farming. However, despite the positive flock selection bias adopted in this study there was still considerable scope for improvement in basic husbandry practices, for example, only one farm was able to avoid watery mouth problems without resort to routine antibiotic prophylaxis at some stage during the lambing period. Another area which requires further client education is the overall approach to assistance given during second stage labour. Too much reliance is placed upon routine antibiotic treatments administered to ewes after manual investigation and correction of dystocia. Too few farmers used the simple routine of washing their hands with an appropriate disinfectant such as povidone iodine and using a lubricant before investigating the cause of dystocia. The use of disposable plastic arm length sleeves is a step in the right direction.



One of the major factors in the overall management and husbandry standards of the flocks studied was undoubtedly the number of sheep per attendant. This is an area which warrants further attention on most farms.

#### **6.1.4. BACTERIAL INFECTIONS**

Losses greater than 3% caused by bacterial infections contracted in the perinatal period extending from the umbilical vessels or entero-invasion were encountered on three of 20 farms. On each farm a combination of poor environmental hygiene and wet lambing pens resulted in a high prevalence (up to 10%) of joint lesions in two to six week-old lambs. Group B streptococci were isolated from joint samples on one farm and there was no serological evidence of erysipelas infection. A representative number of ewes from each of these three flocks had been blood sampled for serum 3-OH butyrate concentration between three and five weeks pre-lambing and were classified as adequately fed at that time. Inadequate colostrum accumulation should not, therefore, have been important in the epidemiology of polyarthrititis in these three flocks.

A very low incidence of hepatic necrobacillosis or liver abscessation was recorded in these three flocks. The lack of umbilical or hepatic abscessation may suggest that the bacteraemia originated from the gut following entero-invasion. This postulate could not be investigated further but all three farmers claimed that they maintained a strict navel dipping policy. Each lamb that was examined revealed evidence of iodine staining but the effectiveness or timing of such treatments could not be determined in older lambs.

Protective immunoglobulins accumulate in the colostrum only if the ewe has previously been challenged by that particular organism and has mounted an active immune response. Colostrum samples were not screened for the presence of specific immunoglobulins and therefore it was not possible to extend this investigation further. It is also possible that low concentrations of passively-derived specific immunoglobulins could have been overwhelmed by a severe bacterial challenge.

Spinal lesions resulting in cord compression, whether due to epidural abscess formation or vertebral body abscess, were less common than joint lesions but because of the lack of treatment response such lesions represented a high percentage of lamb losses on one farm. Intensive antibiotic treatment as outlined by Rebhun and de Lahunta (1982) for bacterial infections of the central nervous system was unsuccessful in each spinal lesion case.

#### **6.1.5 PROPHYLACTIC ANTIBIOTICS**

The extent to which widespread use of prophylactic oral antibiotics administered during the first few hours of birth prevented the development of bacteraemic conditions could not be determined because treatment and control groups could not be established on the same farm. Most farms adopted the procedure of prophylactic antibiotic administration within the first 30 minutes of life as outlined by Eales et al., (1986). Certain antibiotics, namely the aminoglycosides, which are the most frequently used group of antibiotics in neonatal lambs, are not absorbed from the gut lumen (Huber, 1988). The aminoglycosides would be ineffective in controlling a bacteraemia originating from the umbilical vessels or in the treatment of a bacteraemia once it had become established.

It is possible to postulate that amoxycillin is a more suitable antibiotic to administer orally to lambs soon after birth than an aminoglycoside antibiotic as it is readily absorbed from the gut. Once minimum inhibitory concentrations of amoxycillin have been reached in the serum and tissues the number of neonatal infections which result from localisation of bacteraemia and septicaemia may be reduced.

The effectiveness of the different antibiotics which were used routinely for the prevention of watery mouth was not studied because watery mouth can be largely controlled by sound husbandry practices. The routine use of prophylactic antibiotics has become widely adopted in intensive livestock production systems but such indiscriminate use of antibiotics has to be seriously questioned, particularly in neonatal lambs.

#### **6.1.6 WATERY MOUTH**

Based on the interpretation of the flock mean serum 3-OH butyrate concentration three to five weeks prior to lambing the high incidence of watery mouth in lambs encountered on some farms was not related to dam undernutrition during late pregnancy. The aetiology of watery mouth in such flocks is, therefore, not simply the result of inadequate dam colostrum accumulation due to underfeeding in late pregnancy but includes such factors as delayed or inadequate consumption of colostrum by the lamb and/or overwhelming environmental bacterial challenge.

Few intensively-managed, housed flocks were able to contain the incidence of watery mouth to acceptable levels by the standards of hygiene and husbandry that were practised on their farm. The increasing dependence on routine antibiotic administration to control watery mouth is a disturbing trend that has developed over the past ten years and

should not be condoned. Alternatives to antibiotic administration such as probiotics (Asby, McEwan and Wilson, 1989; Jensen, 1990) and metoclopramide (Scott, 1988a) warrant further investigation.

There has been little support from the veterinary profession for the use of probiotics for a number of reasons including the lack of scientifically-conducted field trials and the promotion of such products by agricultural trade merchants. There is an obvious need for more field trials to assess the usefulness of probiotics specifically for the prevention of watery mouth. If the efficacy of probiotics can be proven in carefully controlled trials the veterinary profession should support their use in preference to antibiotic prophylaxis.

Fortunately, at present watery mouth is caused by opportunistic coliforms and is not due to multiple antibiotic resistant bacterial strains of E. coli. However, there is a disturbing trend that as the lambing period progresses antibiotics such as neomycin or streptomycin no longer prove effective in controlling watery mouth and that antibiotics such as furazolidone or apramycin are necessary. In intensively-reared calf units the routine prophylactic use of oxytetracycline and other antibiotics in milk replacer is considered by some workers to have resulted in the pre-eminence of Salmonella typhimurium 204c which has multiple antibiotic resistance patterns and results in high mortality rates amongst affected calves. Once S. typhimurium has become established in a calf unit it is extremely difficult to eliminate.

Rotavirus has recently been identified as a cause of neonatal diarrhoea in lambs. Rotavirus infection leads to desquamation of enterocytes

lining the upper small intestine resulting in severe loss of intestinal absorptive capacity and reduced secretion of lysozymes and other protective proteins. Certain antibiotics, many of which are used for watery mouth prophylaxis, for example neomycin and chloramphenicol are known to reduce the mitotic rate of the small intestine crypt cells thereby aggravating the problem caused by rotavirus infection.

It is worthy of note that few cases of bovine neonatal diarrhoea, with the exception of enterotoxigenic E. coli (ETEC), justify the routine use of oral antibiotics. Farmers are aware of the severe check in lamb growth rate that results from an episode of neonatal diarrhoea but may in fact exacerbate the problem with antibiotic therapy, especially if such treatment is continued for a number of days. Fluid therapy, flunixin meglumine and parenteral antibiotics such as penicillin may represent a more sensible and effective treatment regimen than certain oral antibiotic preparations.

A recent report of the Scottish Veterinary Investigation Service (SVIS) (Anon, 1991) suggests that hypogammaglobulinaemia was possibly the underlying problem in a flock which experienced a high incidence of joint ill lesions caused by E. coli. This report is incomplete as it fails to recognise a number of important points: entero-invasion may have occurred before the lambs sucked colostrum or there may have been normal immunoglobulin absorption but an overwhelming bacterial challenge from dirty environmental conditions. Furthermore, as entero-invasive E. coli are largely opportunist organisms there is unlikely to be specific colostral immunity. The absence of specific E. coli strains which cause neonatal infections is the major reason why commercial E. coli vaccines have failed to confer significant protection. By assuming

the aetiology of joint infections to be hypogammaglobulinaemia and inferring poor colostrum supply to be the sole aetiological factor other equally important epidemiological factors would be overlooked. Such reports confuse rather than aid veterinary advisors.

The important finding of this study that the majority of lamb losses are caused by management factors and not by infectious disease are in broad agreement with the conclusions of McKenzie and Grant (1976).

The incidence of congenital abnormalities, except for entropion, was low and in agreement with the incidence reported by Dennis (1985). The conclusion (Rook et al., 1990) that congenital abnormalities rarely contribute to major perinatal losses is supported by this study.

## **6.2 ABORTION**

### **6.2.1 BORDER DISEASE**

Despite a high prevalence of seropositive flocks to border disease virus (Sands and Harkness, 1979) clinical evidence and positive virus isolation of border disease virus was only encountered in two farms in this survey, both of which had experienced confirmed cases of mucosal disease in cattle. A link between cattle infection with mucosal disease/bovine viral diarrhoea and sheep with border disease virus has recently been reported (Carlsson, 1991). The low incidence of clinical border disease precluded control on financial grounds. Positive feedback is reported to be unsuccessful in controlling border disease virus in sheep flocks (Bonniwell et al., 1987). Control of mucosal disease/bovine viral diarrhoea by culling all virus-positive cattle is underway on both farms and this may reduce the incidence of border disease virus in sheep.

### 6.2.2 TOXOPLASMOSIS

Apart from two farms which experienced an abortion rate of 15%, abortions caused by toxoplasmosis were only encountered sporadically. Neither of the flocks with a high incidence of toxoplasma-induced abortion experienced an increased perinatal lamb mortality rate compared to previous seasons. Analysis of pre-sucking serum samples to determine the incidence of foetal toxoplasma infection was not undertaken. The recent report of polymerase chain reaction (PCR) technology (Wheeler et al., 1990) will greatly assist investigations of the role of T. gondii in perinatal lamb mortality in the future.

While specific split flock data are not available from this survey the low incidence of toxoplasma abortion in those flocks fed concentrates medicated with monensin, as described by McColgan and Buxton (1986), suggests that this is a worthwhile prophylactic measure. By feeding monensin sodium during late pregnancy and lactation there is, in addition, benefit from the control of coccidiosis in the lambs and improved feed utilisation in the ewes (Austin and Wilde, 1985).

### 6.2.3 CHLAMYDIA PSITTACI

Despite the strict implementation of a chlamydial vaccination programme by the majority of the farms involved in this study, chlamydial abortion continues to be a source of lamb mortality. This lack of vaccine efficacy against chlamydial abortion has also been questioned by Linklater and Dyson (1979).

The beneficial response to strategic antibiotic administration during late gestation in flocks with endemic chlamydial abortion (Rodolakis et al., 1980) was only observed in that small number of flocks in this



series which experienced a high abortion rate in the control group of between 3-13%. Close examination of field data (Grieg et al., 1982) reveals that a significant prophylactic treatment effect was achieved in only one flock and that this treatment was administered within one week of the anticipated lambing date. From the results in this series conducted over two years it is unlikely that prophylactic antibiotic administration would be cost-effective unless the incidence of chlamydial abortion was above 5%.

Problems arise when deciding on an intervention level for prophylactic treatment as the incidence of chlamydial-induced abortion varies from one season to another. A figure of 2% incidence of chlamydial-induced abortion which has occurred one month before lambing is suggested. The results from this series demonstrated a large percentage of abortions occurred within one week of the prophylactic antibiotic injection which was administered three weeks before the anticipated lambing date. The administration of the antibiotic injection four weeks before lambing would appear, therefore, to be a more appropriate time.

#### 6.2.4 SALMONELLA SPECIES

Overall, the abortifacient agents encountered in this study were not considered to contribute significantly to the lamb perinatal mortality rate which is in agreement with the findings of Gumbrell (1985). However, individual flock infections with S. montevideo and S. derby resulted in high lamb losses due to abortion and death of pregnant sheep. Such large losses are similar to those reported for S. montevideo (Linklater, 1983) and for campylobacteriosis (Gumbrell, 1985). The apparent rapid control of an outbreak of S. derby abortion in one flock in this study following the intramuscular injection of a



long-acting oxytetracycline preparation warrants further investigation in other field outbreaks of salmonellosis. A split-flock study was not carried out in this study and therefore the efficacy of the antibiotic therapy is circumstantial.

None of the flocks with an abortion storm due to S. montevideo attempted antibiotic therapy. In each flock control was limited to removing the ewes from the contaminated pasture and treating inappetant sheep with antibiotics. Many of the abortions caused by S. montevideo occurred after week 14 of gestation which is contrary to the findings of Linklater (1986a) who suggested that infection with S. montevideo after week 14 of pregnancy did not result in abortion. Therefore it is essential that methods for the control of S. montevideo infection are maintained during the last six weeks of gestation.

#### **6.2.5 LEPTOSPIROSIS**

Despite the high prevalence of leptospira titres in sheep flocks reported by Hathaway, Little and Stevens (1982), none of the reported clinical signs attributable to leptospirosis (McKeown and Ellis, 1986) was recognised in this study.

### **6.3 COLOSTRUM**

#### **6.3.1 COLOSTRUM SUBSTITUTES**

Commercial colostrum substitutes were administered to prevent watery mouth in weakly lambs on a number of farms with variable results. Two farms which used colostrum substitutes in place of prophylactic antibiotics reverted to antibiotics when the incidence of watery mouth in lambs reached 20%.

There was no evidence from this series of lamb dysentery in the progeny of ewes in low body condition at parturition or in the case of multiple litters. The expense of hyperimmune colostrum substitutes is perhaps questionable and they may well act only as an energy source. However, colostrum substitutes are preferable to milk replacers as they do not produce such a profound hyperglycaemia in the lamb (Eales et al., 1982a).

Unless a problem develops in lambs caused by rotavirus or enterotoxigenic E. coli the use of genetically-engineered colostrum substitutes may not be justified. Recent reports described the isolation of rotavirus from scouring lambs but their significance has still to be evaluated (Anon, 1991). When such viral pathogens become prevalent, as is presently the case in calf diarrhoea, control is likely to be attempted by vaccination of the dam. Prophylactic antibiotic administration to mixed viral and bacterial infections could be contraindicated as many antibiotics are known to slow down the mitotic rate of enterocytes lining the proximal small intestine.

### 6.3.2 BOVINE COLOSTRUM

Many farms in this study fed bovine colostrum to weakly lambs without the occurrence of cases of anaemia as reported by Winter (1989). In one flock in this series severe anaemia in a lamb which had received bovine colostrum was not caused by bovine colostrum. The Scottish Veterinary Investigation Service report (1991) details only one reported case of bovine colostrum-induced anaemia in a lamb and, therefore, the reservations of Winter (1989) may appear to be over-cautious. A much higher percentage of lambs died of starvation, mismothering and exposure which would have benefitted from routine administration of bovine

colostrum within the first 30 minutes of life. Such routine administration of bovine colostrum would provide a readily-digestible energy source to maintain thermogenesis and the laxative properties of colostrum may assist in the prevention of watery mouth by initiating gut motility and facilitating the passage of meconium.

The transfer of specific colostral immunoglobulins occurs when the lamb sucks colostrum but the small intestine is capable of absorbing colostral immunoglobulins for only 24 hours after birth. The initial reports of anaemia in lambs originated from the Netherlands where bovine colostrum is widely used in Maedi-visna control programmes. The true incidence of anaemia in lambs following only one feed of bovine colostrum is probably low. Efforts must be made to ascertain the incidence of bovine colostrum-induced anaemia other than anecdotal reports otherwise an important management aid may be denied farmers.

In this study no anaemia problems were recognised in lambs following the feeding of bovine colostrum. On a number of farms bovine colostrum was fed to all lambs weighing less than approximately 3.5kg. The use of the laboratory tests, sheep red blood haemolysis and agglutination tests (Winter, 1989) were not found to be reliable tests as they revealed a number of false positive reactions.

E. coli septicaemia was a common cause of lamb mortality in the study by Khalaf et al. (1979b) where ewes had insufficient colostrum. The routine administration of bovine colostrum to weakly lambs may have contributed to the low perinatal rate caused by E. coli septicaemia in this study. It is interesting to speculate that bovine colostrum may contain some immunoglobulins which confer some general protection

against ovine E.coli strains. This type of investigation was outwith the scope of the current study. Of equal importance is the fact that bovine colostrum administered to lambs by stomach tube soon after birth provides a readily digestible energy source and stimulus to the lamb to seek the ewe's udder and suck.

Until such time as a reliable test is available to detect the anaemia factor in bovine colostrum it would be prudent to pool colostrum from six to eight cows and then feed newborn lamb aliquots from this pooled source, thereby diluting the amount of colostrum which would be ingested from a single cow which had the anaemia factor.

### **6.3.3 HYPOGAMMAGLOBULINAEMIA**

The study by Khalaf et al. (1979b) demonstrated the high mortality rate of triplet lambs which failed to suck sufficient colostrum. Inadequate passive antibody transfer was reflected in the significantly lower immunoglobulin concentrations at 24 hours old. The overall 25% lamb perinatal mortality rate caused by insufficient dam colostrum/milk supply (Khalaf et al., 1979b) contrasts dramatically with less than 2% mortality caused by starvation in certain well-supervised flocks in this study. In these flocks bovine colostrum was administered routinely to weakly lambs, especially triplets.

A significant reduction in the perinatal lamb mortality rate following the administration of serum collected from old ewes to 36 hours old lambs has been reported (Heath, 1985). Presumably mortality was reduced in the treatment group by the protection conferred by the transfer of immunoglobulins. As the control group was fully vaccinated against the clostridial diseases, neither lamb dysentery nor pulpy kidney could be

the cause of mortality in that group. As the causes of lamb mortality were not detailed it is difficult to comment further on this work. It is difficult to appreciate which immunoglobulins and against what diseases produced such a significant treatment effect, especially as the control of enteric disease in the neonate is primarily attributed to local action of IgA at gut mucosal level. No further report of similar work has appeared in the literature which is surprising when the results obtained could have obvious practical application on many sheep farms.

## **6.4 DYSTOCIA**

### **6.4.1 SUPERVISION**

The maximum interval between observing ewes for signs of first stage labour was two hours and on many farms there was 24 hour-a-day attendance. This level of flock supervision was considered to be a major influence resulting in the low stillborn rate recorded. On some farms the stillbirth rate was less than 2% compared to Meat and Livestock Commission average flock figures of 6-8% (MLC Yearbook 1989, 1990). Regular visual examination of ewes for the start of first stage labour, followed then by digital examination of the posterior reproductive tract if no lambs are produced within one hour of the start of first stage labour, reduces potential lamb losses caused by simple malpresentation or malposture. Delayed first stage labour can produce periods of hypoxia in the foetus and metabolic disturbances especially when the head is engaged in the pelvic canal or constricted by the posterior reproductive tract in cases where there is bilateral shoulder flexion.

Problems associated with initiation of respiration in the neonate following protracted dystocia (Eales and Small, 1980b) were not

recognised in this study. Avoidance of dystocia by early recognition of foetal malpresentation or malposture was considered vital in reducing the prevalence of foetal metabolic problems associated with protracted second stage labour.

The problems associated with impaired thermogenesis following dystocia observed in both calves (Vermorel et al., 1989) and lambs (Vermorel and Vernet, 1985) due to reduced colostrum intake (Edwards, 1982) and reduced thyroid hormone concentrations (Vermorel et al., 1989) was overcome by administering colostrum by stomach tube soon after birth. Lamb warming boxes (Moredun lamb warming box) were used only for premature lambs or very low birthweight lambs. No farm in the study used the Moredun lamb thermometer to determine hypothermia.

The study at Woodhouselea which showed that ewes lamb throughout the whole day illustrates the necessity of constant flock supervision. A compact lambing period whereby 80-90% of ewes lamb during the first two weeks is considered optimal and can be achieved by attention to ewe condition score at mating but most importantly the provision of sufficient fertile rams which remain sound throughout the service period. Best results in this study were achieved by farms which ran three or four rams as a group with one hundred or so ewes. Problems were encountered on two farms where a subfertile ram working alone resulted in a prolonged lambing period for that group of ewes.

It is possible that a high incidence of dystocia (Gumbrell, 1985; Wilsmore, 1986) and trauma during the birth process indicates lack of experienced supervision throughout the day and excessive manual interference when dystocia cases are identified. These studies

(Gumbrell, 1985; Wilsmore, 1986) arrive at totally different conclusions regarding the importance of dystocia as a cause of perinatal mortality compared to the present survey. The major difference is because of the bias employed in flock selection in the studies by Gumbrell (1985) and Wilsmore (1986) who adopted a problem-orientated approach. In United Kingdom flocks it is surely more relevant and productive to demonstrate sustainable high performance achieved by excellent stockmanship than to investigate high perinatal losses where the cause is simply poor management whether the result of poor breed selection resulting in dystocia or lack of skilled supervision.

#### 6.4.2 LITTER SIZE

The predominance of multiple litters in the hybrid ewes in this survey resulted in a low incidence of dystocia caused by relative or absolute foetal oversize. The average litter size in flocks in this study was in the region of 2.0 lambs and the risk of absolute foetal oversize is virtually eliminated in multiple births. Relative foetal oversize was avoided by strict selection of breeding stock and by not breeding from ewe lambs. The causes of dystocia in the surveys conducted by Gumbrell (1985) and Wilsmore (1986) were not reported, however, the fact that 74% of all perinatal mortality cases showed evidence of trauma during the birth process (Gumbrell, 1985) is totally unacceptable. Similarly, a dystocia rate of 50% with 17% perinatal lamb mortality (Wilsmore, 1986) requires serious re-appraisal of farm management and veterinary supervision. Unfortunately, no details of lamb birthweight or the degree of dystocia are provided in either of these studies.

In this study dystocia was not a major cause of stillbirths or lamb perinatal mortality. No increase in stillbirth rate in association with



increased lamb birthweight as reported by Alexander, McCance and Watson (1955) was noted. The influence of dystocia due to foetal oversize in single bearing ewes was low and in agreement with the findings of Robalo Silva and Noakes (1984). In a large commercial flock study veterinary assistance was available at virtually every parturition recorded (Barlow et al., 1987) but was either not required, or minimal.

In the small percentage number of dystocias attended during this study, the degree of manual interference before veterinary assistance was requested was thought to have a major influence on the ewe and lamb survival rate. In one flock excessive manual interference by the farmer resulted in uterine rupture in two of six dystocia cases. All six dystocias were corrected by caesarian operation but because of the delay in requesting veterinary assistance all the lambs were dead on delivery. The six ewe hogs made an uneventful recovery after surgery. These findings support the conclusion of a previous study (Scott, 1989) that when there is a dystocia veterinary assistance must be sought promptly to ensure a successful outcome of ovine caesarian operations. In this particular flock relative foetal oversize resulted from the use of a Suffolk ram on Scottish halfbred ewe lambs rather than the choice of a South Down ram.

#### **6.4.3 LAMB BIRTHWEIGHT**

While breeding females can be selected for a reduced incidence of dystocia using the criteria outlined by Quinlivan (1971) and Fogarty and Thompson (1974), on a commercial scale selection of the ram is the simple and well-proven solution. Absolute foetal oversize was not reported as a problem by any farmer in this survey. This reported low incidence was supported by the low number of caesarian operations performed because of absolute foetal oversize.



In this survey no evidence was found to suggest that an adequate plane of ewe nutrition during late pregnancy resulted in a high dystocia incidence caused by absolute foetal oversize in singleton pregnancies. There is the traditionally held opinion that "overfeeding" results in "big singles" and "bad lambings". Such a relationship may exist in purebred flocks such as the Suffolk or Texel but no such correlation was identified in this study in hybrid commercial flocks. Furthermore, there is no such condition as a "bad lambing", only excessive interference by an ignorant shepherd who fails to recognise that a caesarian operation is indicated.

With the exception of foetal monsters absolute foetal oversize was not an important cause of dystocia and perinatal mortality in this study. Results of lamb birthweight studies would indicate that supplying adequate energy to single-bearing ewes during late gestation resulted in an increase in birthweight of only 0.1kg compared to the offspring of moderately underfed ewes (Russel et al., 1977).

An increase in lamb birth weight of only 0.5kg resulted from raising the level of ewe nutrition from a low to high energy input (Khalaf et al, 1979b). Any increases in the mean lamb birth weight of a flock, resulting from supplementary feeding during late pregnancy, are not likely to be due to increases in foetal growth rate but arise because progressive decreases in rate are prevented (Mellor, 1983). In other words, adequate dam nutrition during late gestation results in good lamb birthweights which, even in the case of singletons, does not result in a significant increase in dystocia rate or lamb perinatal mortality.

## 6.5 PLACENTATION

### 6.5.1 NUMBER OF PLACENTOMES

The average number of placentomes and average placental weights in this study varied widely but were in the same range as previous reports (Alexander, 1964; Stegeman, 1974; Rhind et al., 1980). In this series there was no significant relationship between placental weight or cotyledon number with dam nutrition, lamb birthweight or lamb viability. Mellor (1983) reported that placental weight varies widely in uniformly treated ewes and much of the variation remains unexplained. From results in the present study placental measurements do not appear to be a useful practical guide in the investigation of dam nutrition or lamb perinatal mortality.

McDonald, Robinson and Fraser (1981) reported the presence of a wide range of foetal sizes at any particular gestational age in uniformly treated ewes.

The influence of dam nutrition during the period 30-90 days of gestation on placental development was not studied in this series because all the ewes in the flocks were managed in a similar way. In addition, blood parameters such as serum 3-OH butyrate or plasma glucose concentrations are not useful guides to energy adequacy during early pregnancy due to the lack of significant metabolic demand. Despite similar nutritional management there was a wide range of placental weights (factor of four to five times variation) within a flock. It is possible that the small placental weights resulted from a disparity of uterine distribution associated with foetal mortality (Rhind et al., 1980) and the inability of compensatory growth to occur. However, such a large variation in placental weights would seem unlikely.

The practice of collecting the placentae following the completion of third stage labour may have introduced some error in the determination of placental weight as placental weight decreases by about 50% during the first two to three hours after placental separation (Mellor, 1983). The collection of placentae immediately into watertight bags may have reduced this loss of weight but this could not be verified.

These observations on varying placental weights provide some indirect support for the findings (Stegeman, 1974) that while the placental weight may not increase during late gestation there are important functional changes in perfusion which influence placental nutrient exchange. Such compensatory mechanisms may allow similar lamb birthweights despite different placental weights.

#### **6.5.2 LAMB BIRTHWEIGHT**

There was little within-litter variation of twin lamb birthweights in this series. This may indicate that few of the twin pregnancies were originally triplets with the subsequent loss of one embryo/foetus. The presence of two embryos in the same uterine horn results in a reduced number of attachment points on the endometrium for each foetus and subsequent reduced birthweight of those lambs (Dingwall et al., 1987). If one foetus is lost, this results in a marked disparity between the remaining foetus and the original single foetus in the contralateral uterine horn. This disparity in foetal size results because the compensatory increase in cotyledon weight in such a situation is insufficient to correct for a deficiency in the original number of cotyledons (Rhind et al., 1980). Typically, in such a situation lamb birthweights would be in the region of 5.0kg and 3kg to 4kg whereas twin

birthweights usually only vary by 0.2kg to 0.6kg largely depending upon sex of the foetus.

### 6.5.3 PLACENTAL FUNCTION

Certain problems were encountered in the study of placental function; firstly, it was not possible to be certain that all the placentae had been collected as placentae could easily be lost in the deep straw bedding or the ewe often ate some. Secondly, in a multiple birth it was not possible to attribute a particular placenta to a particular lamb. Thirdly, there was a wide range of placental weights and occasionally only one large placenta was collected from a twin pregnancy. Close examination of such a placenta revealed a bilobed appearance and what appeared to be an area of fusion. In this area there were few sparse cotyledons which were smaller than those of other areas of the placenta. A wide range of placental weights (a factor of 4-5) made interpretation of these data difficult as even the lowest placental weights, in the region of 250g, were capable of supporting a viable foetus to full term.

The wide placental weight range reported in this series is difficult to explain as the nutritional status of all sheep within a flock at the time of placental development was largely similar as far as could be practically determined. In spring-lambing flocks mated in mid-October placental development occurs during mid-November to mid-January when there is still autumn grass and supplementary hay is fed during adverse weather conditions. In addition, assessment of previous nutritional status in the monitored flocks by condition scoring at housing six to eight weeks before lambing revealed ewes to be in reasonably good bodily condition. Often condition scores were greater than 2.5 and there was little variation of body condition within flocks. Such a small

difference in body condition would not be expected to be related to such a large, five-fold variation in placental weights.

From the results obtained in this study little practical information was gained by measuring placental weight or cotyledon number. It was concluded that nutrition alone would not account for the four to five fold difference in placental weights and that, in addition, fusion of adjacent placentae may occur in a number of cases.

The zoonotic risks from pathogens which cause placental and foetal infections must always be considered when handling such material and for this reason alone placental measurements are unlikely to be of much benefit to the veterinary flock advisor.

## **6.6 LITTER SIZE**

### **6.6.1 FACTORS INFLUENCING LITTER SIZE**

Each of the farms in this study provided improved grazing conditions for two weeks before and during the mating period in an attempt to increase the number of ovulations, the conception and implantation rates and consequently litter size. A range of body condition scores of 2.5 or above is associated with a litter size of around 2.0 (Speedy et al., 1980). The value of the tradition of "flushing" ewes pre-mating is open to serious question because few farms can properly manage a normal lamb crop without attempting to increase it. Comparison of the production data recorded by the Meat and Livestock Commission (MLC Yearbooks 1989, 1990) indicate the number of live lambs weaned per 100 ewes put to the ram as 155 compared to a potential crop of around 200 (Speedy et al., 1980). While a number of factors such as ewe barren rate, ewe mortality

and abortion rate influence the number of live lambs born, perinatal lamb mortality still remains the most important area of loss.

It would be foolhardy to increase the number of lambs born alive if no effort was made to increase lamb survival rate in the first few days of life.

On many farms between 5% and 10% of the lamb crop are raised as orphan lambs or sold at market for a sum which often does not cover costs of transportation. Typically, by late March orphan lambs are valued at between 50p to £5.00 each. Those orphan lambs which are not sold and are reared on the farm are susceptible to a wide range of digestive tract disorders during early life including abomasal bloat and/or torsion. Coccidiosis is a problem frequently encountered later in such a lamb rearing system.

The question has to be asked why on many farms does the lambing percentage (lambs reared per 100 ewes to ram) rarely exceed 155 yet these farms often have more than 5% of the lamb crop as orphan lambs throughout most of the lambing period. Time devoted to the feeding of orphan lambs would be more profitably spent preventing losses rather than the age-old tradition of "twinning-on" orphan lambs.

#### **6.6.2 FATE OF ORPHAN LAMBS**

There are no figures reported in the literature as to the performance to weaning of fostered lambs. At Woodhouselea the initial acceptance rate while the ewe and her lambs were still penned together was 17/21 (81%); no figures were available after turnout to grass. Fostering is greatly assisted by using the skin of the dead lamb to cover the orphan lamb but, by definition, this method means that a lamb has been lost and such a loss may well have been prevented.

Most farmers reported that some foster lambs were rejected by the ewes after turnout and such lambs then had to be reared artificially. In addition, foster lambs were sometimes found dead after adverse weather conditions due to inadequate nutrition caused by rejection by the ewe. It was estimated that between 5-20% of foster lambs were rejected after turnout. It would appear that the success rate of fostering lambs is in the region of 50-75% although this will vary depending upon management factors such as levels of supervision, provision of adequate shelter and lamb creep feeding from two weeks of age.

### **6.6.3 TRIPLET LAMBS**

Few farms are capable of managing ewes with triplet lambs for a number of reasons. Firstly, milk supply, or more correctly colostrum accumulation at birth, may not be adequate for three lambs. Supplementary feeding of triplet lambs is frequently necessary as demonstrated in the results of the study at Woodhouselea. Secondly, manual correction of simple dystocia cases is more common in triplet-bearing ewes and if this procedure is not performed observing strict hygiene procedures it may result in metritis. Due to the vague clinical signs associated with such uterine infections, metritis may remain undetected until the ewe becomes completely agalactic. The clinical signs of metritis include reduced appetite, poor milk yield and reduced maternal behaviour. Thirdly, the weather during late March/early April is often such that ewes with triplet lambs are held in pens for the first two to three days after lambing. During this time the lambs are continuously exposed to bacterial pathogens especially coliforms. Fourthly, mismothering is common amongst ewes nursing triplets unless the ewe and her lambs are confined in small paddocks (less than one hectare) containing only 6-10 other ewes and are well shepherded.



Farmers regularly report an increased incidence of acute gangrenous mastitis in ewes rearing triplets and are consequently reluctant to allow ewes to nurse three lambs. The aetiology of gangrenous mastitis in ewes is thought to be the result of trauma to the teat caused by excess sucking behaviour by hungry lambs and subsequent bacterial invasion of the streak canal. The pathogens most frequently isolated are Staphylococcus aureus, a commensal of ovine skin or Pasteurella haemolytica, a commensal of the lambs' oropharynx particularly the tonsillar crypts. To a certain extent, the problem of teat lesions can be overcome by ensuring high milk yields by providing the ewe with good grazing supplemented with a sensible concentrate allowance of 0.5-0.6 kg fed three times daily. The provision of creep feed for the lambs from two weeks of age will reduce the total dependence of the lambs on dam milk yield. One farm in this survey employed this management practice and in most years 8-10% of ewes successfully reared triplets. In late grazing seasons, such as 1991, this figure dropped to 5% of ewes.

Unless the farmer is prepared to devote extra labour, feed and grazing resources to triplet lambs this management system must not be recommended. Furthermore, ewes nursing triplets must not be regarded as balancing those nursing singletons in the vain hope of a 200% lambing percentage and impressing one's neighbour.

The philosophy that a triplet lamb can be added to a ewe with a single lamb or to replace a lamb that has died is entrenched in farming tradition but it could be reasoned that such a practice simply adds to the management problems at lambing time rather than reduces them. This situation is discussed from a financial viewpoint below.



Under optimal conditions single lambs are capable of rapid growth and will reach carcase weights of 22kg by ten weeks of age (from early June onwards) and attract a good market price (around £44 at 1991 prices). Unless the foster lamb is born synchronously to the singleton "twinning on" is both difficult and time consuming, often necessitating confinement in a "lamb adopter pen" for between three to five days. During this time the milk yield of the confined ewe drops dramatically and the good single lamb is given a severe check in growth rate from which it is unlikely to recover and will, therefore, not achieve market weight until mid August when lamb prices are at the seasonal low. As discussed earlier, rejection of foster lambs is common. The use of a dead lamb's skin to aid fostering considerably improves the acceptance rate but also indicates the avoidable loss of a lamb in the first instance.

Furthermore, the financial benefits of a ewe nursing triplets compared to a ewe nursing twins is less attractive than at first appears. The lambs' growth rate in the first weeks of life is positively correlated with birthweight (Penning, Corweraa and Treacher, 1980) therefore triplet lambs grow less quickly. Again, with good management twin lambs can be ready for market at carcase weights of between 17 to 19.5kg during late June at circa £2.00/kg resulting in circa £75/ewe gross output. Triplet lambs are most unlikely to reach a suitable degree of finish until mid September onwards at approximately 18.5kg unless creep feeding is provided. The total value of three lambs in mid September may not exceed £95. The extra variable costs of feeding, anthelmintic treatments and grazing area allocated to lambs post weaning reduce the benefits of triplet lambs to as little as £5-10 gross margin per ewe.

Energy feeding of the ewe during late pregnancy has a carry over effect on lamb daily liveweight gain for at least three weeks after birth (Khalaf et al., 1979a). Twins and triplet lambs from ewes on a high plane of nutrition grew 31% faster than the progeny of ewes on a low plane. The maximum growth rate of twin lambs reported by Khalaf et al. (1979a) of 317g/day is, however, well below the target value of 450g/day achieved by some of the high output management systems investigated in this study.

A number of studies have demonstrated that the bodyweight of lambs at four months of age is closely related to the birthweight (Penning et al., 1980; Barlow et al., 1987). Once again, however, the performance of lambs is directly attributable to farm management policy, for example grazing management, control of parasitic gastroenteritis and prevention of trace element deficiencies. Some flocks in this study achieved lamb daily liveweight gains almost twice that reported by Barlow et al. (1987). Indeed one flock studied in detail sold over 75% of lambs at average carcase weights of between 18.0 and 21.5kg by 11 weeks of age.

Unless some triplet-bearing ewes are going to successfully rear triplets the whole philosophy of flushing pre-mating is highly questionable. This statement is supported by the data of Khalaf et al. (1979a) where the perinatal lamb mortality of twin lambs from well-fed ewes was 0% compared to 41.6% for triplet lambs from ewes on a low plane of nutrition.

#### **6.6.4 FLUSHING**

It is possible that the abundant grass used to flush ewes could be more beneficially utilised on the farm to finish store lambs and that ewes at

mating time should be more tightly stocked. Approximately 150g of barley per head per day could be provided during early pregnancy (during December and January) to maintain ewe body condition. Supplementation of the concentrate feed during this period with monensin sodium may assist in reducing early embryonic losses caused by T. gondii infection which may be a widespread, yet unrecognised, cause of a high barren rate (Johnston, 1988).

A positive farm management decision should be made regarding those ewes nursing a single lamb. As reported above, such lambs are capable of very high liveweight gains (approximately 500g/day) and command a relatively high market price in late May/early June. Once weaned, these ewes can be very tightly stocked at 20 to 30 ewes per hectare for the remainder of the summer. Alternatively, as these ewes would be weaned early and have had a dry period of approximately six weeks, they could be programmed with progesterone sponges for mating in July/August to produce finished lambs for the early spring market. In the future melatonin could be successfully used for early season breeding of crossbred ewes managed in this way.

Flushing may result in a high number of triplet- or quadruplet-bearing ewes. The linear relationship between perinatal lamb mortality and litter size is well illustrated in the results of Khalaf et al. (1979b). During late pregnancy prolific ewes are more susceptible to ovine pregnancy toxaemia, vaginal prolapse (Hosie, 1989) and rupture of the prepubic tendon compared to ewes with singles or twins. The results from this study showed that rupture of the prepubic tendon was always associated with a triplet or quadruplet pregnancy. In each of these conditions the response to induction of parturition with glucocorticoids

was poor. The conclusion reached by Robinson et al. (1977) that the optimum number of lambs produced in a single pregnancy is less than the maximum number that can be produced is more applicable in the current agricultural situation than it was almost fifteen years ago.

Surprisingly, little attention has been paid to this excellent work by veterinary and agricultural advisers.

The removal of the variable premium in 1992 to be replaced by further increases in the ewe premium again questions the value of flushing ewes at mating time. The philosophy that an initial high lamb crop will compensate for lamb losses at lambing time is misplaced and needs to be reviewed. In the future it is possible that sheep management systems will go one of two ways: those flocks with a high input/high output producing class Q lambs for marketing in June/early July and attracting a financial premium and low input/low output systems producing store lambs which would be marketed from mid-September onwards. A large lamb crop in the latter system could be potentially disastrous due to the low feed inputs which are demanded in a low cost system.

Perhaps the major benefit of improved nutrition for two weeks prior to mating and for the following six to eight weeks is not the increased ovulation rate or the successful implantation of the embryo(s) but the fact that the ewe gains substantial body condition before winter. Such increased body reserves, mainly in fat depots, are then used to balance small energy deficits during mid and late gestation. It is generally accepted that it takes six weeks on good grazing for a ewe to gain one unit of condition score (Hindson, 1982). There is no conclusive evidence in the veterinary literature that a ewe body condition score

greater than 3.0 is detrimental to ewe health and production during late pregnancy.

It is somewhat ironic that the substance androstenedione, which results in an increased ovulation rate and marketed as Fecundin(R) (Coopers Pitman Moore), has recently been removed from the veterinary market due to poor sales figures. The most frequent complaint about Fecundin was the increased percentage of triplet pregnancies, yet on the other hand farmers still adhere strictly to flushing programmes which generate the same end result. Tradition is taken to its ultimate limit by the provision of free-access, high phosphorous "tupping" minerals at mating time to ensure high ovulation and conception rates and large litters. In 1984 the imposition of milk quotas within the European Economic Community (EEC) caused dairy farmers in the United Kingdom to realise that pushing dairy cows to extremes of production by high concentrate input may not yield the best net profit figures. In dairy farming today the emphasis is firmly placed on high grassland management efficiency both in terms of grazing management and conservation, with low concentrate inputs. The recent changes in the variable premium and ewe premium payments suggest that lamb production will follow a similar pattern of reduced inputs especially feed costs. The triplet-bearing ewe would be most at risk from any management decision which reduced concentrate input. Field studies are necessary to investigate the extent to which altered grassland management practices during late summer and early autumn can increase the percentage of twin pregnancies yet reduce the incidence of triplet and quadruplet pregnancies.

A somewhat similar situation of unwanted twin lambs has developed in those hill flocks where improved grazing resulting from re-seeding and

Time application has increased the twinning rate. These twins are unwanted because it is not possible to return ewes with twins to the hill. As there is an heritable component to twinning, by retaining ewe lambs from twin litters there is the likelihood that the problem will become compounded.

#### **6.6.5 REAL TIME ULTRASOUND SCANNING**

Only two farms in this study employed ultrasound scanning as a management tool. The accuracy recorded on one of these farms was very disappointing and effectively rendered the results useless emphasising the critical importance of the operator.

Ultrasound scanning has been widely adopted by hill farmers where it permits improved nutrition during late pregnancy and more detailed supervision of twin-bearing ewes at lambing time. Single-bearing ewes are left on the hill. On lowground farms, ultrasound scanning may also have an application but in differentiating twins from triplets thereby permitting preferential feeding of triplet-bearing ewes. The results from this study showed that ewes with triplets were more prone to vaginal prolapse, severe underfeeding and ovine pregnancy toxæmia when compared to twin-bearing ewes in the same flock. Following scanning, a representative number of triplet-bearing ewes should be selected and included in the flock monitoring scheme and sampled for serum 3-OH butyrate concentration five to six weeks and again three weeks prior to lambing.

## 6.7 POST PARTUM LAMB LOSSES

### 6.7.1 LAMB BIRTHWEIGHT

The results produced by certain farms in this study would contest the statement that "it is well established that mortality rates are high in lambs with birth weights below the breed norm" (Mellor, 1983 who quotes work by Purser and Young, 1959, 1964, Gunn and Robinson, 1963, Alexander, 1974, Houston and Maddox, 1974, Khalaf et al., 1979b).

Firstly, it is important to eliminate those low lamb birthweights caused by prematurity. Prematurity can only be differentiated by accurate recording of the dam's service date and to a lesser degree by detailed examination of the lamb for short coat length and reduced thermogenesis and respiratory function indicating poor adaptation to extra-uterine existence. Secondly, in the last decade considerable advances have been made in supportive care of the neonate which have markedly reduced the perinatal mortality rate. Such measures include the widespread use of donor colostrum administered by stomach tube and the provision of warming boxes (Eales et al., 1982a). In some situations intraperitoneal glucose can be life-saving as in the case of hypoglycaemic lambs. Housing of ewes and 24 hour a day supervision is now routinely practised in the majority of lowground units which reduces the incidence of dystocia and the physiological and metabolic problems which may result from a protracted birth.

The results of this study indicate that with correct supervision lambs with birthweights as low as 2.5kg can survive. These results are in general agreement with the findings of Barlow et al. (1987) who report that low birthweight is not in itself a primary cause of death but where there is any disease or physiological incapacity it may be an important contributory factor.



### **6.7.2 HYPOTHERMIA**

The early ingestion of colostrum is especially critical in premature lambs due to their increased susceptibility to fatal hypothermia (Eales et al., 1982b) and more so in newborn lambs which have been deprived of nutrients before birth (Mellor, 1983) due to dam undernutrition during late pregnancy.

### **6.7.3 PREMATURITY**

In this series the birth of premature lambs was associated with a marked increase in the lamb perinatal mortality rate despite all efforts at supportive care and the use of various therapeutic agents. Similar high mortality rates among premature lambs have been reported (Dawes and Parry, 1965; Eales et al., 1982b). Retention of meconium and the development of abomasal distension/atony were considered indicative of poor development of the gastrointestinal tract in the premature lamb. Future studies should perhaps consider the potential application of metoclopramide to initiate gut motility in premature lambs (Scott, 1988). The administration of corticosteroids to premature lambs in this study, in an attempt to stimulate normal central nervous system, pulmonary and intestinal development (Breazile et al., 1988), was largely unsuccessful.

### **6.7.4 PHYSIOLOGICAL CLASSIFICATION OF PERINATAL LOSSES**

The physiological classification for the causes of death of lambs in a well-managed, commercial flock (Barlow et al., 1987) is interesting because two of the four categories recognised, namely placental insufficiency and acute intrapartum hypoxaemia appear to be outwith any flock control measures. Such physiological problems in the neonate contributed to a lamb mortality rate of approximately 11%. However,



some flocks in the current study achieved perinatal lamb mortality rates of less than 3%. Such low perinatal lamb mortality rates should not have been possible if placental insufficiency and acute intrapartum hypoxaemia are as prevalent as Barlow et al. (1987) postulate.

Why does this major difference in lamb mortality rates of 11% versus 3% arise? In particular, what prepartum factors are responsible for placental insufficiency and acute intrapartum hypoxaemia?

The flock studied by Barlow et al. (1987) was defined as adequately-fed, was housed at night and under 24 hour supervision during the lambing period. However, despite such management 12% of the lamb deaths were the result of inadequate thermogenesis and 13% of starvation. Such events are more likely to result from management problems rather than antemortem physiological state. It is difficult to appreciate how antenatal events could cause such high lamb mortality. Specifically, why should placental insufficiency occur in single-bearing ewes? Problems with placental insufficiency would surely be more common in triplet lambs but this was not the case. The study by Barlow et al. (1987) should be repeated in other flocks before any further action is taken on their conclusions.

#### **6.7.5 COLOSTRUM**

No attempt was made in this study to measure colostrum supply other than by checking the lambs for signs of hunger. It was not uncommon to find an apparent poor accumulation of colostrum in the udder at the end of second stage labour but within two hours there was a plentiful supply. This was considered to be caused by delayed milk let-down which is under considerable physiological control. The use of oxytocin to stimulate

milk let-down was used on a number of farms to collect colostrum from donor ewes as detailed in the field work by Mellor and Murray (1986).

The majority of triplet lambs born at Woodhouselea were judged to be hungry and were stomach tubed with bovine colostrum. This extra work with triplet lambs places an additional burden onto a shepherd's already considerable workload. As none of the ewes at Woodhouselea nursed three lambs and less than one third of triplet lambs were used as foster lambs the influence of triplet lambs on farm profitability is perhaps overstated. The delivery of lambs following a simple dystocia did not interfere with the ability of these lambs to suck sufficient colostrum.

No cases of lamb dysentery were encountered on any farm in this study. This may reflect the low prevalence of the causal organism or more probably the efficacy of the vaccination policy and transfer of sufficient protective immunoglobulins in the colostrum. It has been postulated (Mellor and Murray, 1986) that colostrum supply which is inadequate for thermogenesis may well contain sufficient protective immunoglobulins against clostridial infection. This would explain the absence of lamb dysentery in the offspring of those ewes which produced insufficient colostrum (Khalaf et al., 1979a).

#### **6.7.6 DAM NUTRITION**

In the study at Woodhouselea 11 of 15 ewes which produced twin litter birthweights of less than 8kg were classified as adequately-fed during late gestation hence factors other than energy supply can result in low lamb birthweights. The condition scores of these ewes were generally greater than 3.0 at housing eight weeks before lambing and did not differ significantly from the other ewes in the group. It is therefore

unlikely that nutritional constraints during mid pregnancy could account for the reduction in lamb birthweights as energy underfeeding would also be expected to influence body condition score. It is possible that genetic factors could be involved in the aetiology of low lamb birthweights. It would be interesting to monitor the litter birthweights of these particular ewes in subsequent years.

Studies at Woodhouselea revealed only eight of 184 twin litters with a 1.5kg discrepancy of lamb birthweights where one lamb weighed less than 3.5kg. Such a low birthweight may indicate that early foetal loss had occurred from that uterine horn. The presence of two embryos in one horn reduces the number of uterine attachment points (caruncles) and after the loss of one embryo/foetus compensatory growth of the other remaining foetus does not occur. In such a situation a disparity of lamb birthweights, for example 4.8 and 3.0kg, may be expected. The interpretation of such data would suggest that early foetal loss was not prevalent in this study.

At Woodhouselea approximately 10% of twin-bearing ewes were classified as severely underfed within one week of lambing but produced total litter birthweights greater than 8.0kg. In this situation a short period of energy underfeeding may have reduced the potential lamb birthweights but is unlikely to contribute significantly to the perinatal mortality rate. In flocks with a lambing percentage of 160-170% with few triplet pregnancies, short-term nutritional deficiencies would not be as critical as for those flocks with a potential lambing percentage of 200-210% where 15-30% of ewes are carrying triplets.

### 6.7.7 BACTERIAL INFECTIONS

The degree of protection afforded by a certain circulating immunoglobulin concentration in the lamb is to some extent dependent upon the level of environmental challenge. For a given immunoglobulin concentration less protection is afforded where the environmental challenge is high.

Only a relatively small number of lambs in this study developed a bacteraemia or septicaemia in the neonatal period which resulted in death. These results are contrary to the report of Khalaf et al. (1979b) who reported a high incidence of perinatal mortality from E. coli septicaemia. However, in the present study mortality was particularly high in cases of enteric colibacillosis which caused endotoxaemic shock, colloquially referred to as watery mouth (Eales et al., 1986). Only one farm in this series did not use oral antibiotics for the control of watery mouth. It is possible that such routine prophylactic use of antibiotics reduced the incidence of E. coli septicaemia in those flocks.

The fact that E. coli is the bacterial pathogen most commonly isolated from lambs which died of a septicaemia in the first two days of life (Khalaf et al., 1979b; Eales et al., 1983) would indicate that entero-invasion is the most probable route of entry for these bacteria.

### 6.7.8 WATERY MOUTH

The build-up of environmental bacterial contamination is the major factor in the epidemiology of watery mouth. This statement is supported by the following observations. Firstly, the incidence of watery mouth increases very rapidly after the first week to ten days of the lambing

period. Secondly, the incidence is highest in those flocks with poor standards of hygiene and thirdly, a marked reduction in the incidence of watery mouth can be achieved by changing the lambing accommodation or simply lambing outdoors in a clean field.

In this study the provision of adequate dam colostrum alone did not prevent watery mouth in every situation. This is possibly because the coliform organisms involved in the aetiology of watery mouth are opportunist pathogens to which the dam had not previously been exposed, or the level of bacterial challenge overwhelmed the protection afforded by the colostral immunoglobulins or the enteric infection was well established before the ingestion of colostrum. The level of environmental challenge may be an important factor as circumstantial evidence suggests that paraformaldehyde added to the straw bedding in the lambing shed twice weekly may reduce the incidence of watery mouth compared to previous years. Each management control procedure is preferable to the widespread and indiscriminate use of prophylactic antibiotics.

The field study of the use of metoclopramide in the prevention of watery mouth indicated that the early establishment of gut motility may be an important factor in reducing the prevalence of watery mouth in neonatal lambs. It is possible that the laxative property of colostrum could be as important as the immunoglobulin concentration. This physical property may explain the field observations that watery mouth is usually associated with retained meconium and can be prevented in some situations by the use of laxatives such as Beecham's pills or the administration of a soapy water enema. Such prophylactic measures are effective where there is a relatively low bacterial challenge, however,

as the lambing period progresses there is a rapid rise in the level of environmental bacterial contamination. The subsequent success of prophylactic antibiotics indicates the role of bacterial infection in the multi-factorial aetiology of watery mouth.

The E. coli strains involved in watery mouth outbreaks are usually opportunist organisms and not obligate pathogens. At present the development of multiple resistant strains of E. coli would seem unlikely because there is only one susceptible population annually, the buildings are not continually occupied as is common in calf-rearing enterprises and few flocks buy in young lambs which could be potential carriers of bacterial or viral enteropathogens. Until such time as the routine administration of prophylactic antibiotics to lambs is restricted there appears to be no urgency on the behalf of either the farming industry or veterinary profession to apply sound husbandry measures to control watery mouth.

#### **6.7.9 NECROPSY FINDINGS**

The interpretation of necropsy findings were frequently complicated by stomach tube feeding of moribund lambs. This management practice presented necropsy findings of an abomasum full of milk but a carcass largely devoid of fat stores, especially perirenal fat. The post mortem methodology described by Rook et al. (1990) which details the interpretation of necropsy findings was especially useful in establishing the cause of death in such lambs and is recommended to veterinary surgeons involved in sheep preventive medicine programmes.

The common necropsy finding of an abomasum distended with milk may indicate that milk substitute is inappropriate in the treatment of

recumbent, weakly lambs. As milk substitute requires digestion before absorption, the use of electrolyte solutions may be more appropriate. Such electrolyte solutions have been successfully used for the treatment of neonatal problems in calves. Many farmers failed to appreciate the volume and frequency of oral fluid treatments necessary to rehydrate weakly, dehydrated lambs. The addition of glucose powder to raise the final concentration of the oral fluid to 10% has been recommended (Eales et al., 1987).

Hypothermia was an uncommon contributing factor to perinatal mortality in this study because the majority of flocks were housed during the lambing period. Starvation, however, was a common contributing factor to perinatal mortality cases on some farms. Identification of failure to suck was made more difficult by the poor design and inadequate lighting of the lambing pens on these farms. Too often the lambing pens were constructed of fork lift pallets tied together with string. Access to these pens was unnecessarily difficult and as a consequence the lambs were not examined as frequently as they should have been. The siting of such pens in the corners of buildings away from direct overhead lighting made examination of sheep in these pens difficult during darkness, which in late March, lasts almost 12 hours per day.

#### **6.7.10 PREVENTIVE MEASURES**

Those farms with very low perinatal lamb mortality rates used the following common protocol after each lambing. The navel of each lamb was fully immersed in strong iodine solution immediately following birth. This procedure was repeated two to four hours later when the abomasum of the lamb was palpated transabdominally to determine whether the lamb had sucked colostrum. The abomasum of the newborn lamb



comprises 85% of the forestomachs' volume. If the lamb had not sucked, either the ewe was milked after the intravenous administration of 5iu oxytocin, or cow colostrum was used as a substitute. Fifty mls/kg bodyweight of colostrum was administered to each lamb by stomach tube. After stomach tubing all lambs were encouraged to suck themselves from the ewe two to four hours later. If this was unsuccessful the lambs were stomach tubed again with colostrum.

Immersion of the umbilicus in strong iodine solution resulted in a brittle appearance by 36 hours old and was a very useful indicator of the effectiveness of such husbandry procedures.

#### **6.7.11 HYPOGLYCAEMIA**

None of the farms in this study found it necessary to resort to intraperitoneal glucose administration (Eales et al., 1982a) to treat hypothermic, hypoglycaemic lambs. A number of factors are considered relevant to this topic. Firstly, few farmers were confident of the procedure of intraperitoneal injection despite veterinary instruction. Secondly, coliform-induced endotoxaemia (watery mouth) was a more common cause of moribund lambs than hypoglycaemia and the distended, thin-walled abomasum which develops in the terminal stages of watery mouth could easily be damaged accidentally when attempting intraperitoneal injection. Leakage from the abomasum in such cases would result in acute peritonitis and possibly death. Thirdly, hungry lambs were generally detected before marked hypoglycaemia developed.

Problems of inadequate thermogenesis that occur in lambs born to severely-underfed dams (Alexander, 1964) were reduced in this study by ensuring adequate dam nutrition and by feeding cow colostrum to small



birthweight lambs within the first two hours of birth. The practice of routine stomach tubing small, weakly lambs with colostrum was adopted at Woodhouselea where 50% of triplets born were given colostrum by stomach tube and such lambs had a low perinatal mortality rate.

#### **6.7.12 STILLBIRTH**

The significance of stillborn lambs as a contributing factor to perinatal mortality was difficult to determine because under apparently similar management systems there was a wide variation in stillbirth rate from 1% to 14%. The three flocks with the highest stillbirth rate had endemic chlamydial abortion but the prophylactic administration of a long-acting antibiotic preparation during late gestation to some groups of ewes did not significantly reduce the number of abortions nor the stillbirth rate when compared to control groups in the same flock.

No detailed examination of the stillborn lambs or dam serology for evidence of chlamydial infection was undertaken as difficulty arises in the interpretation of such data in vaccinated flocks. The significance of chlamydial infection in reducing lamb viability is, therefore, difficult to determine. Prior antibiotic administration to ewes in flocks with endemic chlamydial abortion has significantly reduced the perinatal mortality rate in other studies (Greig et al., 1982).

Flock supervision may have had some influence on the stillbirth rate as the two flocks with very low stillbirth rates had excellent standards of husbandry but the difference of 0.5% versus 6-15% in the other flocks could not be wholly attributable to competence of the shepherd.

### 6.7.13 PREMATURITY

The occurrence of a large number of stillbirths during the week immediately preceding the official lambing date would indicate that prematurity is a contributing factor in stillbirths. Between 22% and 51% of flock stillbirths were produced during this week. It is interesting to note that few weakly lambs were reported in this study. This could be explained by the fact that few weakly lambs survived parturition or, more probably, were unable to adapt to extra-uterine existence and were found dead very soon after birth and reported by the farmer as stillborn. Few lambs which were born before day 140 of gestation survived.

Hypothermia was an important problem and a major cause of mortality in premature lambs in this study despite all efforts of supportive therapy. Seven of 12 lambs which died of inadequate thermogenesis (Barlow et al., 1987) showed evidence of pathological changes which suggested prenatal influences. This situation contrasts with full-term lambs where hypothermia was not considered to be a contributing factor to the perinatal lamb mortality rate.

Based on physiological criteria, Barlow et al. (1987) concluded that 71% of lamb deaths in an adequately fed, well-supervised flock with a perinatal mortality rate of 17% were attributable to prenatal factors. This situation is difficult to accept because such high lamb mortality figures of approximately 12% would then be expected in all adequately-fed, well-supervised flocks and this is clearly not the case.

Despite evidence of hypoxaemia and increased plasma lactate concentrations (Barlow et al., 1987) which may indicate disturbed foetal

metabolism, no evidence of meningeal haemorrhage was noted at necropsy. This is contrary to the findings of Wilsmore (1986) who attributed perinatal losses to metabolic disturbances and resultant meningeal haemorrhage.

One of the recommendations (Barlow et al., 1987) to reduce lamb mortality is to ensure placental development during 30 and 90 days of gestation. In the flock they studied most ewes lambed in a condition of between 2.0 to 3.0 which would indicate adequate nutrition especially for ewes with multiple pregnancies. If a ewe lambs in a condition score of 3.0, there is little evidence to suggest that nutrition during 30 to 90 days of gestation has been grossly inadequate.

#### **6.7.14 ADVERSE VACCINE REACTION**

Routine vaccination against the common clostridial diseases and pneumonic pasteurellosis may be a cause of premature births in a small number of flocks. A recent report in the Veterinary Record (Anon, 26th October 1991) describes the investigations carried out by Dr Suttle on the death of ewes following vaccination in the winter of 1989/90 (Veterinary Record, 4th May 1990). Dr Suttle reported that in all cases associated factors including poor nutrition, pregnancy toxemia, hypocalcaemia and liver disease contributed to the ewe deaths.

None of the flocks reported by Dr Suttle was monitored before vaccination, therefore, evidence of a pre-existing metabolic disease such as liver dysfunction and the degree of undernutrition could not be confirmed. The role of handling stress is emphasised in Dr Suttle's report.

Dr Suttle reported that in experiments vaccination with the combined clostridial and pasteurella vaccine reduced food consumption although specific figures are not quoted in this report (Veterinary Record, 26th October 1991). It was postulated that the vaccine may contain endotoxins which may have contributed to ewe deaths. Endotoxaemia results in a marked reduction in the plasma glucose concentration which may have contributed significantly to the liver pathology and aggravated a marginal energy deficiency situation. If cases of adverse vaccine reaction occur in the future it would be interesting to study the effect of flunixin meglumine, an anti-endotoxin drug in the treatment regimen.

Evidence to support the postulate that adverse vaccine reactions can occur was provided by one farm in this study which was under direct veterinary supervision. In this flock routine sampling revealed the ewes to be adequately fed (Russel, 1985) four weeks before lambing (mean serum 3-OH butyrate concentration of 0.4mmol/l). Some of these ewes were triplet bearing. Vaccination carried out under strict adherence to the manufacturer's instructions resulted in ten of 240 ewes showing inappetance over the following two to three days. Serum 3-OH butyrate concentrations measured from six ewes four days after vaccination were markedly raised (greater than 6.0mmol/litre) yet the majority of these ewes were bright, alert and grazed normally when turned onto a grass field. During the following four weeks four of the ten ewes did not eat concentrates yet carried their lambs to full term. One of these ewes subsequently nursed triplets. This report is not typical of the clinical picture of an hepatic encephalopathy associated with ovine pregnancy toxemia. The six other ewes in this group lambed prematurely, two of which subsequently nursed a single triplet foster lamb.

In the author's experience ovine pregnancy toxaemia is generally observed in three-crop ewes and older in association with triplet pregnancies. At the time of presentation for veterinary attention such ewes are in very poor bodily condition, often less than score 2.0. Investigation of the diet often reveals poor quality forage and a low energy allowance from concentrate feed. Blood sample analysis from a random sample of clinically normal sheep always reveals some ewes which are severely-underfed. The treatment response of ovine pregnancy toxaemia cases to intravenous glucose infusions, oral electrolyte solutions and attempted induction of parturition with glucocorticoid injections is invariably disappointing. Death, without abortion of foetuses, is the common sequel in ovine pregnancy toxaemia cases.

This clinical picture of ovine pregnancy toxaemia is different to that experienced in the flock detailed above which appeared to experience an adverse vaccine reaction. The majority of the sheep in this flock were twin-bearing with a mean body condition score above 2.5. The theoretical concentrate metabolisable energy (ME) contributed 9 MJ ME/head/day to the ration, five weeks before lambing when daily ewe maintenance and foetal requirements are approximately 13 MJ ME/head/day. The hay offered ad libitum should have been more than sufficient to meet the energy deficit of 4 MJ ME/head/day without taking into account any energy contribution from catabolised body reserves.

Blood sample analysis of a representative number of ewes revealed that they were adequately fed (mean serum 3-OH butyrate concentration less than 0.4mmol/l). Six of ten ewes lambed prematurely which is an uncommon sequel to ovine pregnancy toxaemia even after attempted

induction of parturition with glucocorticoids. Ewes which have had ovine pregnancy toxemia and give birth to live lambs are rarely able to nurse a lamb due to the considerable loss of bodily condition that has occurred and the very poor mammary development. It would be most unlikely that a ewe with ovine pregnancy toxemia could nurse triplets.

The use of a live attenuated parainfluenza-3 (PI3) intranasal vaccine has been recommended for the control of pneumonic pasteurellosis in sheep (Rodger, 1989).

While it is recognised that bovine ketosis can be secondary to a wide range of clinical diseases it is assumed that ovine pregnancy toxemia is primary in all cases. The incorporation of levamisole into the clostridial vaccine (Nilvax, Coopers Pitman Moore) permits the clostridial vaccination programme to be completed before the critical last six weeks of gestation. The immune-potentiating effect of levamisole has been widely recognised (Ovadia, Flesh and Nelken, 1978; Saperstein, Mohanty, Rockeman and Russek, 1983).

## **6.8 EWE LAMB BONDING**

### **6.8.1 GIMMERS**

In this study genuine problems of ewe-lamb bonding were only encountered in a relatively small number of gimmers which rejected one twin lamb. In the majority of such cases correction of a malpresentation or malposture had necessitated handling of the sheep by farm staff. While this manipulation had been performed quietly and the sheep penned with her lambs immediately afterwards, rejection of one lamb could still occur. At the beginning of the lambing period overcrowding of the lambing accommodation frequently resulted in the first born lamb

becoming "lost" while the second lamb was being born. Closer supervision and penning of the ewe and her lambs immediately after the completion of second stage labour largely overcame this problem of mismothering.

#### **6.8.2 PEN DESIGN**

As discussed earlier, improvements in lambing pen design are overdue on most farms. Solid pen partitions are essential to permit ewe-lamb bonding without the attention of another sheep on the other side of a barred division. Easy access to lambing pens is essential to check that the lambs have sucked colostrum and for routine procedures such as navel dipping, docking and castration, cleaning and disinfection.

#### **6.8.3 CHEMICAL RESTRAINT**

The sedative drug, azaperone, administered intramuscularly to foster ewes, gave inconsistent results when used to facilitate fostering lambs. While chemical restraint of ewes to enable a lamb to be fostered could be difficult to support ethically, this method may be preferable to the physical restraint methods which employ rope halters or "lamb adopters" where the ewes are confined for up to six or seven days. A number of beta-adrenergic agonists have recently been developed for the chemical restraint of animals, particularly dogs and horses, and an appropriate agent may soon be available for sheep. However, as emphasised throughout this thesis, attention to every aspect of flock management and reducing losses will have a much greater impact than future chemotherapeutic developments whether they are sedatives, anti-prostaglandins or antimicrobial preparations.



#### **6.8.4 BODY CONDITION**

No relationship was recognised between body condition and mothering ability. Frequently in this survey, ewes in low condition score 1.5 to 2.0 would successfully rear the triplets they had produced. In addition, in the hill flocks in this practice ewes are often in poor bodily condition at lambing but will defend their lamb(s) vigorously. Maternal instinct would appear to be lowest in gimmers, but this problem may result more from the unfamiliar management systems of close confinement at lambing time rather than with the sheep.

Some problems with ewe-lamb bonding occurred when triplet lambs were fostered onto ewes which had produced singletons. No problems were encountered when a foster lamb, which was still wet, was covered with the amniotic fluid from a newly-delivered singleton. If more than three hours had elapsed since the birth of the single lamb or the triplet lamb was more than 12 hours old, fostering was considerably more difficult and rejection was common. These field observations are similar to the findings of Mellor (1988).

### **6.9 MASTITIS**

#### **6.9.1 MASTITIS INCIDENCE AND CONTROL**

Mastitis was controlled on the farms in this study by the routine administration of intramammary antibiotics at weaning (Hendy and Pugh, 1981) and the culling of ewes with chronically-infected glands at the pre-breeding examination. On one farm failure to use an intramammary antibiotic at weaning resulted in a 4% incidence of mastitis which was discovered at lambing time. Induration of the affected mammary gland meant that ewes which had produced twins could only nurse one lamb.



## **6.10 PARTURITION**

### **6.10.1 SYNCHRONISATION OF PARTURITION**

The compact nature of the lambing period and the provision of 24 hour per day supervision removes any requirement for the synchronisation of parturition with either epostane (Silver, 1987) or clenbuterol (Plant and Bowler, 1988). With strict attention to ewe body condition at mating, ram fertility and a low ewe to ram ratio (25:1) 85% of the flock should lamb within the first 10-14 days of the lambing season. Such a compact lambing period then justifies the employment of additional skilled assistance during this period.

### **6.10.2 MANAGEMENT FACTORS**

A compact lambing necessitates at least one lambing pen per four ewes which was only provided on a small number of farms. In the study conducted by Asby et al. (1989) 40% of lambs required to be individually penned with their dams for more than four days before turn-out to pasture. Such a high percentage of ewes retained for such a long time would seriously increase penning requirements.

The lack of a concrete base made cleaning of the lambing pens extremely difficult, time-consuming and expensive as regards the use of straw. Disinfection of lambing pens was rarely carried out.

## **6.11 CENTRAL NERVOUS SYSTEM LESIONS**

### **6.11.1 DYSTOCIA**

No evidence was found in this study to support the hypothesis that dystocia could cause subdural, subarachnoid or extradural haemorrhages resulting in impaired feeding, locomotor and metabolic activity which

collectively contribute to the starvation, mismothering, exposure complex described by Haughey (1985).

No explanation could be found as to why dystocia could result directly in central nervous system haemorrhages. The development of subcutaneous oedema of the lamb's head is common in neglected ovine dystocia cases (Hindson and Winter, 1990) and is frequently associated with delayed correction of lambs in anterior presentation with bilateral shoulder flexion. Despite the extent of this subcutaneous oedema, correction of the dystocia and good supportive care of the lamb ensures a favourable prognosis, while lack of flock supervision will result in death of the lamb due to extended second stage labour.

It is unlikely that haemorrhages in the central nervous system could be the result of direct physical trauma as the brain and spinal cord are well protected in the cranium and vertebral column. Similarly, epicardial haemorrhages are observed in cases of the starvation, mismothering, exposure complex yet there is no traumatic injury to the rib cage. Conversely, fractures of the ribs at the costo-chondral junction may result from dystocia, especially when lambs are in posterior presentation, yet frequently no epicardial haemorrhages are observed at necropsy. It is more probable that the central nervous system haemorrhages observed in starvation, mismothering, exposure cases result from the intermittent hypoxia associated with the dystocia. This hypoxic state results in blood capillary fragility and subsequent haemorrhage (Wilsmore, 1986). If this is the case, central nervous system haemorrhages are indicative of neglected dystocia cases and a direct indication of management incompetence.

In the study by Khalaf et al. (1979b) which reported a perinatal lamb mortality rate of 29%, only 1% of deaths was associated with dystocia. This study illustrates that management of neonatal lambs is more important than the incidence of dystocia. Problems arise with the interpretation of dystocia data because there is no standard system of grading the severity of ovine dystocia. For example, with a multiple birth simple postural abnormalities frequently result in dystocia and would be recorded as such an event. Conversely, absolute foetal oversize caused by a large single lamb would also be recorded as one dystocia event. The latter would have a considerably greater negative influence on lamb survival.

#### **6.11.2 NEUROLOGICAL SIGNS**

The extent of central nervous system haemorrhage which results in death remains unknown. Despite the widespread distribution of central nervous system haemorrhages (Wilsmore, 1989) specific neurological syndromes (Braund, 1985) have not been described in neonatal lambs. In the perinatal period the clinical signs exhibited by moribund lambs of depression, muscular weakness, hyperpnoea are more suggestive of endotoxaemia (Hodgson et al., 1988) and/or hypoglycaemia (Eales et al., 1982b) than of specific neurological deficits. A typical example of the expression of a specific central nervous system lesion would be that of multiple cranial nerve deficits of ptosis, drooped ear, reduced facial muscle tone resulting from a brainstem lesion.

The pathophysiology of intracranial haemorrhage has not been adequately explained by either Haughey (1985) or Wilsmore (1989). The presence of a central nervous system excitatory focus as in meningitis can result in a period of hyperaesthesia and convulsions which may progress to coma

and death. This range of clinical signs has not been reported for cases of intracranial haemorrhage. The duration of clinical signs of meningitis in lambs is in the region of three to five days (Scott, 1990) while lambs with central nervous system haemorrhage are reported to die within the first few hours of life.

Clinical signs of a space-occupying lesion in the central nervous system have not been described in neonatal lambs and, therefore, it is not possible to know what significance to attribute to pressure damage alone in the central nervous system of the ovine neonate. The increase in intracranial pressure as a consequence of coe neuriasis in the cerebrum results in the gradual appearance of clinical signs of circling, depression or excitation and contralateral blindness (Skerritt and Stallbaumer, 1984) rather than the acute clinical signs observed in the starvation, mismothering, exposure complex.

The conclusion from this survey is that dystocia is an uncommon cause of perinatal lamb mortality. Continuous 24 hour per day supervision is vital to correct simple cases of foetal malpresentation or malposutre and thereby avoid unduly protracted periods of second stage labour which cause alterations in foetal metabolism. Central nervous system haemorrhages are not described as an important necropsy finding in cases of perinatal mortality in field studies (Barlow et al., 1987) and in reference text books (Jensen and Swift, 1989; Martin and Aitken, 1991).

#### **6.11.3 BOVINE STUDIES OF CENTRAL NERVOUS SYSTEM HAEMORRHAGE**

Central nervous system haemorrhage has not been recorded as a cause of perinatal mortality in the bovine despite a high prevalence of dystocia (Gee, Gaden and Harper, 1989) and the use of considerable traction

forces. The use of a head rope to facilitate correction of a foetal malposture, which might be expected to cause trauma to the cervical vertebral column and spinal cord does not appear to result in any CNS trauma or adversely affect calf survival. Damage to peripheral nerves resulting in temporary paralysis is the more common sequel to bovine dystocia (Ciszewski and Ames, 1987). In the calf, femoral nerve paralysis following dystocia is usually unilateral and results from damage to the nerve itself rather than from haemorrhage within the spinal cord.

#### **6.11.4 CEREBROSPINAL FLUID**

As an adjunct to the ovine study, cerebrospinal fluid was examined from seven cases of neonatal bacterial meningitis in calves which were born following a protracted dystocia. Analysis of cerebrospinal fluid samples failed to reveal evidence of red blood cells or xanthochromia which would have indicated central nervous system haemorrhage.

#### **6.11.5 HISTOPATHOLOGICAL EXAMINATION OF THE CENTRAL NERVOUS SYSTEM**

Histopathological examination of the central nervous system failed to reveal evidence of central nervous system haemorrhages. There was, therefore, no support from this small study that in the bovine intracranial haemorrhage occurred as result of protracted dystocia.

In this study bacterial meningitis in lambs was considered to result from entero-invasion associated with poor environmental hygiene and delayed acquisition of sufficient colostrum. No reference to intracranial haemorrhage associated with meningitis could be found in reference pathology textbooks (Jubb, Kennedy and Palmer, 1985).

In the author's experience of bovine dystocia cases, calves which are delivered alive but with severe oedema of the head resulting from protracted second stage labour can be given a good prognosis provided there is excellent supportive care. No specific central nervous system neurological deficits have been observed in such cases although femoral nerve damage has been observed on a number of occasions.

#### **6.11.6 SPECIES SUSCEPTIBILITY TO CENTRAL NERVOUS SYSTEM TRAUMA**

No explanation could be found in the literature for the reported different susceptibility of lambs and calves to dystocia-induced central nervous system haemorrhages. In the author's experience anterior presentation with bilateral shoulder flexion is an uncommon cause of dystocia in cattle but relatively common in sheep. Such a malposture may cause compression of the jugular veins and carotid arteries resulting in hypoxia-induced capillary damage in the brain. This would result in poor tissue perfusion of the head caused by the build up of venous back pressure and the compression of the jugular veins would explain the development of cranial oedema.

This hypothesis would not explain the occurrence of haemorrhages within the caudal spinal cord described by Wilsmore (1989). Further work may be necessary to clarify the significance of central nervous system haemorrhage and the type and severity of dystocia. However, such work may be difficult to justify when it has been clearly demonstrated in this series that a low incidence of stillbirth or perinatal loss can be achieved simply by diligent stockmanship and the provision of 24 hour-a-day supervision by suitably qualified and motivated staff.

### 6.11.7 CENTRAL NERVOUS SYSTEM LESIONS IN FOALS

Considerable research work has been carried out in the new-born foal relating to central nervous system function and the significance of central nervous system haemorrhage but there would appear to be a poor correlation between the clinical signs observed and the site of the central nervous system lesion.

The aetiology of neonatal maladjustment syndrome in foals is incompletely understood but is considered to be the result of a variety of central nervous system insults including subarachnoid haemorrhages, neuronal necrosis and oedema (Mayhew, 1982; Palmer et al., 1984). Affected foals display signs of cerebral dysfunction (Rossdale, 1969) but other neurological signs can be observed (Mayhew, 1989). Such specific neurological signs have not been reported in lambs with central nervous system haemorrhages. However, in foals dying after neonatal maladjustment syndrome there is often a poor correlation between the clinical signs indicative of a central nervous system lesion and the presence of hypoxaemic-ischaemic brain damage at that site (Mayhew, 1988). While the histopathological changes of central nervous system haemorrhage and oedema are similar in the foal and lamb there is considerable variation in the observed clinical signs.

While seizure activity is a common finding in neonatal maladjustment syndrome in foals (Mayhew, 1989) such behaviour has not been reported in lambs where the typical clinical findings are depression with impaired feeding and locomotor activity. Hence, while the central nervous system histopathological changes observed are similar in both species, the clinical findings appear to be completely opposite. It is difficult to attribute the differences in clinical signs solely to species



differences. It is more likely that central nervous system haemorrhages indicate previous hypoxia which result in metabolic changes due to impaired cardiovascular/pulmonary function which could result in hypoglycaemia, disturbances of acid/base balance and electrolytes which, if they exceed the seizure threshold, result in convulsions (Clement, 1987). Some support for metabolic disturbances contributing to perinatal mortality is presented in the results of Barlow et al. (1987).

## **6.12 PREMATURITY**

### **6.12.1 PREMATURITY DUE TO ADVERSE VACCINE REACTION**

On one farm in this study there was an inverse relationship between lamb birthweight and perinatal mortality. The lower lamb birthweight group experienced a high mortality rate because of premature birth caused by an adverse dam reaction to clostridial vaccination two weeks earlier. The possibility of premature birth must be considered when investigating low birthweight as a cause of perinatal mortality.

Certain other management practices must also be considered when investigating the relationship between birthweight and perinatal mortality: namely the smallest triplet lamb is usually removed from the litter and used as a foster lamb or reared as an orphan lamb. The mortality rate of the former group is increased due to dam rejection and susceptibility to starvation, mismothering and exposure complex and the latter group to coliform infections and digestive tract disturbances including abomasal bloat and torsion. On many farms in this study full-term lambs with birthweights as low as 2.5kg did not experience an increased perinatal mortality rate when appropriate supportive care was provided.



## **6.13 EWE NUTRITION**

### **6.13.1 CONDITION SCORING**

In this study condition scoring six weeks prior to lambing was an unreliable guide to the ewes' current nutritional status. Low body condition scores can result from slight undernutrition throughout mid-pregnancy and/or moderate to severe-underfeeding during the weeks immediately prior to the condition scoring date. For this reason analysis of serum 3-OH butyrate concentrations is a more accurate assessment of the ewe's current nutritional status. Various recommendations are given for optimum body condition scores at this stage of gestation: 2.5-3.0 (Russel, 1985; Hosie, 1989) and 3.5-4.0 (Scott, 1988).

### **6.13.2 EWE LIVEWEIGHT CHANGE**

The significant correlation between ewe liveweight gain and level of energy supply during the last four to five weeks of gestation determined by serum 3-OH butyrate concentration in this study is similar to the findings of Russel et al. (1977). Adequately-fed ewes in this trial gained 6-9 kg during the last month of pregnancy, similar to the value of 10kg whereas severely underfed ewes gained only 2-4kg, similar to the value of 2-3kg (Russel et al., 1977). Lowest liveweight gains during the last month of pregnancy were recorded for severely underfed triplet-bearing ewes which had greatly elevated serum 3-OH butyrate concentrations.

No association was found in this study between ewe condition score determined six weeks pre-lambing and the total litter placental weight recorded at parturition. There was little variation in body condition scores six weeks before lambing as energy requirements prior to that

stage of gestation are largely similar despite foetal number. Energy requirements during mid gestation can usually be met from the provision of ad-libitum good quality roughage such as hay or silage, possibly supplemented by turnips.

### 6.13.3 PLACENTAL WEIGHT

There was no support for the postulate that low energy intake throughout mid-pregnancy, which could result in low body condition scores, was associated with low placental weights. The wide range of placental weights recorded in this study would suggest that factors in addition to mid pregnancy nutrition could exert an influence on placental development. The birth of viable full term lambs associated with low placental weights may indicate that, in the absence of placental infection, placental weight is not a critical factor in determining lamb survival during the perinatal period.

There was no evidence from this study to support the findings (Mellor, Matheson and Small, 1977) that premature birth results from premature increases in foetal plasma cortisol concentration in response to reduced placental transfer of oxygen and/or nutrients. In this study placental weights as low as 250g were associated with the birth of a full-term viable lamb. Premature birth as the result of placental insufficiency was encountered in ewes with C. psittaci placentitis. In this situation premature birth is considered to be the result of reduced placental progesterone production necessary to maintain pregnancy rather than oxygen or nutrient exchange (Aitken, 1987).

In the report of a flock with a neonatal mortality rate of 18% (Barlow et al., 1987) 71% of lamb deaths in the perinatal period were attributed

to prenatal factors: either placental insufficiency or acute intrapartum hypoxaemia, while only 13% of deaths were attributed to postnatal factors. As a large range of placental weights can support a viable foetus to full term the most important factor would, therefore, appear to be acute intrapartum hypoxaemia rather than placental insufficiency. Acute intrapartum hypoxaemia could also explain the central nervous system haemorrhages reported by Haughey (1985) and Wilsmore (1989).

The strict supervision of the flocks studied in this series and the prompt detection and correction of foetal malposture or malpresentation would minimise the risk of acute intrapartum hypoxaemia and may explain the low perinatal lamb mortality rates observed in this study. It is possible that acute intrapartum hypoxaemia associated with prolonged second stage labour could result in a more severe metabolic crisis if associated with a low placental weight. In this situation low placental weight may contribute to an increased lamb mortality rate. While this may be an attractive postulate, it would be difficult to investigate and evaluate in the field situation.

#### **6.13.4 MONITORING LAMB BIRTHWEIGHT**

The assessment of ewe nutrition by measuring the birthweights of the first lambs born each year (Rook et al., 1990) was not found to be a useful practical guide for a number of reasons. Firstly, the first litters born were almost invariably triplets which have a lower individual birthweight but higher total litter weight. Secondly, approximately 80% of ewes lamb within the first 10 to 14 days of the lambing period and improved nutrition for such a short period is unlikely to have a significant effect on lamb birthweights. Thirdly, it is common for the later lambing ewe, especially those which have

returned to the ram for a number of cycles, to produce a higher percentage of singletons. Such improved nutrition for a prolonged period would be economically unjustifiable and could result in an increased prevalence of absolute foetal oversize.

#### **6.13.5 THEORETICAL CALCULATION OF ENERGY STATUS**

The theoretical calculation of energy status (Donoghue and Kronfeld, 1990) was an unreliable guide to the current level of flock nutrition. The main problem with such calculations is determining the energy contribution from the roughage component of the ration: grass, hay, silage, turnips etc. which in many situations contribute up to 50% of the ewe's daily metabolisable energy supply,.

#### **6.13.6 METABOLIC PROFILE TESTING**

The statement by Donoghue and Kronfeld (1990) questioning the usefulness of metabolic profile testing of sheep flocks in clinical practice is somewhat surprising but may be explained by the methods of sheep management and production in the United States of America which is some way behind that of the intensively-managed, high-producing, lowground flocks in the United Kingdom. Sheep production in the United States of America either involves small, family-run units in the Eastern States or large units in the mid-West where the flocks are extensively managed in semi-arid areas such as Utah and New Mexico. Lamb production involves a period of finishing in feedlots, mainly in Colorado, to liveweights in the order of 140-150 lbs (65-70kg approximately) at about 10-12 months of age. There is presently no market for the smaller, lean European type of lamb production.

There was no significant correlation between the serum 3-OH butyrate concentration and change in body condition score. One explanation of this situation could be the narrow range of the condition score change of between 0.3-0.5 units and the range of serum 3-OH butyrate concentrations from 0.3 to 5.0 mmol/l.

#### **6.13.7 SERUM FRUCTOSAMINE**

A recent report has detailed the use of serum fructosamine concentration as a useful prognostic index of ovine pregnancy toxaemia (Cantley et al., 1991). Fructosamine is a stable keto-amine formed when glucose reacts non-enzymatically with amino groups on proteins. The serum fructosamine concentration depends on a number of factors: the serum protein concentration, the plasma glucose concentration and the turnover of fructosamine. In situations where the serum protein concentration remains stable, the serum fructosamine concentration is related to the plasma glucose concentration averaged over the preceding three to four weeks (Armbruster, 1987).

The results of serum fructosamine determinations presented from a study of Welsh mules on a silage diet (Cantley et al., 1991) do not warrant their conclusion that serum fructosamine concentrations might be used as an early indicator of impending pregnancy toxaemia when the serum 3-OH butyrate concentrations are still within normal limits. The clinical signs they described (Cantley et al., 1991) of star-gazing, recumbency and depression are also observed in listerial meningo-encephalitis and polioencephalomalacia. Listerial meningo-encephalitis is an important differential diagnosis of ovine pregnancy toxaemia in silage-fed sheep. Similarly, polioencephalomalacia can occur following the type of dietary change that is encountered when sheep are housed. Gross examination of

the brain with ultra-violet light (Wood's lamp) would demonstrate autofluorescence characteristic of polioencephalomalacia while histopathological examination of the brain stem would reveal the microabscesses characteristic of listeriosis but no necropsies were performed in this study by Cantley et al. (1991).

The occurrence of ovine pregnancy toxaemia in five single-bearing ewes and only one twin-bearing ewe (Cantley et al., 1991) is not typical of the epidemiology of ovine pregnancy toxaemia. Ovine pregnancy toxaemia results from the increasing foetal glucose demand of a multiple pregnancy in ewes fed an energy deficient diet. The reasonable quality silage in the study of Cantley et al. (1991) (ME 10.3 MJ/kg DM) should readily support the energy requirement of a single-bearing ewe three to four weeks before lambing. Furthermore, increased serum fructosamine concentrations result from a persistent hypoglycaemia of perhaps three to four weeks duration (Armbruster, 1987). It would seem unlikely that a single-bearing ewe would be under energy stress eight weeks before lambing when the metabolisable energy requirement is only slightly above maintenance requirement (Clarkson and Faull, 1987). There is no support in the literature that a serum 3-OH butyrate concentration above 2.0 mmol/l (Lindsay and Pethick, 1983) is indicative of ovine pregnancy toxaemia. On the contrary, in the present series 15 flocks had ewes which were classified as severely-underfed (serum 3-OH butyrate concentrations above 1.6 mmol), with many values above 2.0 mmol/l, but clinical cases of ovine pregnancy toxaemia did not occur in these flocks. The extremely low body condition scores in single-bearing ewes of condition score 0.75 (Cantley et al., 1991) three to four weeks before lambing is a matter of concern, however no data are available for the condition scores at housing to allow further interpretation.

In their report Cantley et al. (1991) quote Scott (1988b): "the interpretation of serum 3-OH butyrate concentrations during late pregnancy has proved unreliable as an indicator of impending metabolic crisis under field conditions". However, in the study by Scott (1988b) "cases of pregnancy toxemia were encountered only in the two (moderately-underfed) flocks which contained individual ewes with serum 3-OH butyrate concentrations above 3.0 mmol/l and the Group 3 (severely-underfed) flock". In addition, "the serum 3-OH butyrate concentration was in the range indicative of ovine pregnancy toxemia (greater than 4.0 mmol/l) five to ten days before clinical signs were observed". This work reported by Scott (1988b) involving 37 lowground flocks, clearly demonstrated the accuracy of detecting those flocks which would experience individual clinical cases of ovine pregnancy toxemia.

The reports by Scott (1988b) and Cantley et al. (1991) arrive at the generally similar conclusion that ovine pregnancy toxemia is caused by a prolonged period of undernutrition. However, there would appear to be major differences in the duration and severity of nutritional stress and metabolic demand imposed. The work reported by Scott (1988b) involved twin or, more commonly, triplet-bearing ewes within two to four weeks of lambing whereas Cantley et al. (1991) report predominantly single-bearing ewes three weeks prior to lambing. The metabolisable energy requirement of a triplet-bearing ewe two weeks from lambing is 21 MJ/day compared to 12 MJ/day for a single-bearing ewe three weeks from lambing (Clarkson and Faull, 1987). As the dry matter intake of a heavily pregnant ewe decreases dramatically during the last two weeks of gestation it is possible to appreciate that if insufficient energy is supplied in the form of energy-dense concentrates then ovine pregnancy toxemia may result depending upon the extent of tissue catabolism. It



is less obvious why a seemingly well-fed, single-bearing ewe should develop ovine pregnancy toxæmia three weeks before lambing. Further work is necessary to quantify those factors which affect the serum fructosamine concentration before this metabolite can be recommended as an alternative to serum 3-OH butyrate as the metabolite to monitor for the accurate indication of energy status during late gestation of high producing ewes.

As the fructosamine concentration is lower in animals with a persistent hypoglycaemia of three to four weeks' duration, there is no evidence that this metabolite is a more accurate monitor of energy status and thereby indicates the risk from ovine pregnancy toxæmia. The lower serum albumin concentration in the pregnancy toxæmia group in the study by Cantley et al. (1991) may indicate a period of low protein intake or tissue protein catabolism. The loss of serum protein may have influenced the serum fructosamine concentration. One possible explanation of low serum albumin and the occurrence of ovine pregnancy toxæmia in single-bearing ewes could be chronic fascioliasis. This simple explanation may warrant further investigation.

Ovine pregnancy toxæmia secondary to lameness, poor dentition or systemic disease such as listerial meningo-encephalitis, has not been specifically detailed in the literature although in the field this situation is widely thought to occur. The demonstration of a serum 3-OH butyrate concentration greater than 4.0mmol/l, in addition to signs of central nervous system dysfunction, are not sufficient for a definitive diagnosis of ovine pregnancy toxæmia. A thorough clinical examination, supported by a detailed post mortem examination in unresponsive cases, is essential. Even then the findings at necropsy of fatty degeneration of the parenchymatous organs associated with a multiple pregnancy does



not confirm the diagnosis of ovine pregnancy toxemia. Such necropsy findings could be seen after listerial meningo-encephalitis, polioencephalomalacia and hypocalcaemia which may not be appreciated unless a full investigation is performed.

#### **6.13.8 OCCURRENCE OF OVINE PREGNANCY TOXAEMIA**

Cases of ovine pregnancy toxemia occurred only in those flocks which contained individual ewes with 3-OH butyrate concentrations above 3.0 mmol/l. The low incidence of ovine pregnancy toxemia of between 2-3% of the flock could in part be the result of measures adopted immediately results of routine advisory visits and blood sample analyses were known. However, the effectiveness of this increased energy allowance on the incidence of ovine pregnancy toxemia could not be determined as only a representative proportion of the flock had been sampled and therefore the exact number of other ewes in the flock at risk had not been determined.

Determination of serum 3-OH butyrate concentration three to six weeks prior to lambing proved to be an accurate method of predicting the occurrence of ovine pregnancy toxemia in a flock as cases only occurred in the one severely underfed flock and in those moderately underfed flocks which contained some severely underfed individual ewes (3-OH butyrate concentration 3.0 mmol/l). In addition, no cases of ovine pregnancy toxemia were encountered in any of the adequately fed flocks where the level of energy allowance was maintained or increased as pregnancy advanced.

No attempt was made to reduce feeding costs by reducing concentrate allowance in adequately fed flocks for a number of reasons. Firstly,

the cost savings would be small and secondly, when ewes reach lambing in good bodily condition (condition score range 2.5 to 3.0), body reserves can be efficiently utilised for milk production by incorporating high levels of rumen undegradable protein in the ration.

## **6.14 ANIMAL WELFARE**

### **6.14.1 ANIMAL WELFARE AND MODERN AGRICULTURE**

The whole area of animal welfare has received added impetus in recent months with the launch of the "Farm Assured Scotch Lamb (FASL) Scheme". The Farm Assured Scotch Lamb scheme aims to promote adequate standards of animal welfare and adherence to animal welfare guidelines. Such a scheme is to be applauded as far as it goes, but this is not nearly far enough. The thrust behind the scheme, regrettably, is marketing and not animal welfare.

The change in European Economic Community subsidies from the lamb variable premium to ewe premium emphasises the number of sheep on a farm, not the production characteristics of the enterprise. Low input/low output systems which cannot support an adequate labour force may predominate in less favoured areas in the future. This reduced level of flock supervision may lead to reduced standards of animal welfare.

## 6.15 CONCLUSIONS

The perinatal lamb mortality rate reported in the literature of between 15-25% appears considerably higher than figures quoted by the Meat and Livestock Commission (MLC Yearbooks 1988, 1989). One reason for this discrepancy could be the bias adopted by researchers in selecting flocks with high perinatal mortality rate. In this respect, Rook, Scholman, Wing-Proctor and Shea (1990) stated that much research effort is focused on areas which have little influence on farm productivity. The object of this study was to determine the major problems in large, well-managed, commercial sheep units and to make practical, cost-effective recommendations.

In the survey of commercial flocks, 62% (29 of 47) were adequately-fed during late gestation, 36% were moderately-underfed, with only one severely-underfed flock. Condition scoring of ewes three to five weeks before lambing was not an accurate indicator of the ewes' current energy status. There was no significant correlation between the level of dam nutrition during late gestation and the lamb perinatal mortality rate on the farms studied. However, there was the trend that those flocks which consistently produced excellent results were classified as adequately-fed. The lack of a significant correlation between dam nutrition and perinatal mortality could in part be caused by the arbitrary division between adequately fed and moderately underfed using the serum 3-OH butyrate concentration cut-off point of 0.7 mmol/l. The lack of a sufficient number of severely underfed flocks prevented further analysis of the relationship between dam nutrition and lamb perinatal mortality.

An attempt was made to quantify the level of stockmanship and relate this variable to perinatal lamb mortality. Stockmanship was usually

determined by the flock's performance and, therefore, this relationship could not be defined independently. It was concluded that the maximum number of ewes that could be effectively supervised by one person during the first two weeks of the lambing period was between 80-120.

The contribution of triplet pregnancies to the flock's overall production is seriously questioned. Triplet bearing ewes were more prone to severe underfeeding and ovine pregnancy toxemia and reduced individual birth weights. Triplet lambs were three times more likely to require supplementary feeding with colostrum. Less than one third of triplet lambs were successfully fostered onto ewes with single lambs. As the disadvantages of triplet pregnancies outweigh the benefits of "extra" lambs, the practice of providing improved nutrition before and during the mating period has to be seriously questioned. Ultrasound scanning of high producing flocks to identify triplet-bearing ewes would allow preferential feeding of these ewes to reduce the consequences of underfeeding on lamb birth weights and ewe colostrum supply.

Despite the widespread use of bovine colostrum no case of bovine colostrum-induced anaemia in lambs was recognised in this study. There are considerable cost savings when using bovine colostrum compared to commercial colostrum substitutes when there is insufficient ewe colostrum. There is an urgent need to determine nationally the incidence of bovine colostrum-induced anaemia in young lambs and make recommendations based on this information.

The indiscriminate use of antibiotics in the control of watery mouth is a poor reflection on flock husbandry standards and alternatives such as probiotics must be researched. Simple management factors such as the

construction of properly designed lambing pens is overdue on all farms. The important design features are ready access, good illumination and easy cleaning and disinfection.

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## **INITIAL REPORT**

### **THE POSSIBLE USE OF METOCLOPRAMIDE TO PREVENT WATERY MOUTH IN LAMBS IN COMMERCIAL FLOCKS**

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#### **SUMMARY**

Watery mouth is a major cause of loss in neonatal lambs in south-east Scotland. Metoclopramide given within the first 30 minutes of life reduced the incidence of watery mouth in four flocks when compared to control lambs. In one flock the incidence of watery mouth was marginally higher in the metoclopramide treated lambs. In a further three flocks the incidence of watery mouth was too low to allow any comparisons.

#### **INTRODUCTION**

Sixty-two per cent of all cases of watery mouth occurred within the period 25–36 hours after birth with a further 28% of cases occurring between 37–48 hours old. Single and twin lambs were similarly affected but triplet lambs were three times more likely to be affected. Dam parity had no effect on the incidence of watery mouth in their offspring. As the lambing season progressed newborn lambs were much more likely to develop clinical signs.

The results from this trial and a knowledge of the mode of action of metoclopramide in other species suggests that impaired or delayed function of the digestive tract is an important factor in the aetiology of watery mouth affecting neonatal lambs in commercial flocks in south-east Scotland.

#### **MATERIALS AND METHODS**

The eight flocks in this trial were commercial lowland flocks in east central Scotland. Flock size varied from 30 to 700 ewes. Lambing took place during March and April 1987. In two flocks, A and B, ewes had been housed for at least 8 weeks prior to lambing. In the remainder the ewes were let out into grass fields close to the farmsteading during the day and housed in covered straw yards at night during the lambing period.

Metoclopramide (Emequell<sup>®</sup>, Beecham Animal Health) restores normal coordination and tone to the upper digestive tract and is indicated in the treatment of vomiting in dogs and cats associated with a number of conditions including parvovirus infection, gastritis, nephritis, hepatitis and postoperative recovery.

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The metoclopramide was supplied in a colourless syrup containing 1 mg/ml in glass bottles with an automatic pump which delivered 1 ml per pump. The dose rate was 1 mg metoclopramide per 1 kg body weight. The colourless syrup alone was supplied in similar containers differently labelled and acted as the placebo. Treatments were administered orally to lambs within the first 30 minutes of birth. No antibiotics were administered to the lamb until it showed clinical signs of watery mouth at which time it was recorded and then treated with 40 mg amoxycillin oral suspension (Clamoxyl oral dosers<sup>R</sup>, Beecham Animal Health).

Watery mouth was diagnosed when a lamb displayed the following clinical signs: reluctance or inability to stand, lethargy, reluctance to suck, drooling of saliva and in most cases retention of meconium. Abdominal distension largely due to the accumulation of fluid in the abomasum became more obvious as the condition progressed. Unlike the healthy lamb where milk in the abomasum clots and produces no noise when the lamb is gently shaken, the accumulation of gastric secretions and gas in the abomasum of lambs with watery mouth produces a characteristic rattle. All of the shepherds who took part in this study had had previous experience of watery mouth and were able to accurately recognize this condition. This ability to detect cases of watery mouth was checked during routine visits to each participating farm.

Data which included parity of dam, litter size, incidence of watery mouth and outcome of treatment was entered twice daily on to recording sheets.

## RESULTS

There was a considerable variation in the incidence of watery mouth in both the control and metoclopramide treated groups (Table I). Overall the incidence of watery mouth was considerably less in the treatment group than controls in four flocks. In one flock the incidence was less in the control group and in a further three flocks the incidence was too low to allow a meaningful comparison to be made. The number of cases of watery mouth increased greatly as the lambing period progressed. Farms E and F did not continue with the trial when the incidence of watery mouth in the control group reached unacceptable levels. In both cases oral doses of 40 mg amoxycillin (Clamoxyl oral dosers<sup>R</sup>, Beecham Animal Health) within the first 30 minutes of life resulted in a watery mouth incidence of less than 2%.

Farms A and B discontinued the control treatment when the incidence of watery mouth reached over 40% and 30% respectively. Both farms then used metoclopramide only on all newborn lambs until again the incidence of watery mouth increased to such levels as to warrant the prophylactic use of oral antibiotics.

## DISCUSSION

The results from this trial and a knowledge of specific pharmacological properties of metoclopramide suggest that the development of tone and coordination in the abomasum and small intestine soon after birth are important factors in preventing the clinical condition known as watery mouth. This postulate is in good agreement with field observations of watery mouth cases where clinical examination reveals the presence of

**Table I**  
**Incidence of watery mouth in metoclopramide treated and control groups of lambs in eight flocks**

<i>Flock</i>	<i>Metoclopramide-treated group</i>			<i>Control group</i>		
	<i>Number treated</i>	<i>Watery mouth</i>	<i>Died</i>	<i>Number treated</i>	<i>Watery mouth</i>	<i>Died</i>
W.L.	26	0 0%	0 0%	25	0 0%	0 0%
A	363	6 1.6%	0 0%	65	28 43.0%	4 6.1%
O	132	23 17.4%	2 1.6%	162	24 14.8%	6 3.7%
C	234	4 1.7%	2 0.4%	325	8 2.4%	1 0.3%
B	173	19 10.9%	1 0.6%	179	53 29.6%	0 0%
F	50	0 0%	0 0%	50	5 10%	0 0%
E	100	0 0%	0 0%	100	8 8%	0 0%
E.B.	20	0 0%	0 0%	20	0 0%	0 0%

excessive quantities of clear mucus in the abomasum and the failure to expel meconium. Furthermore, laxatives and enemas have long been regarded as useful preparations in both the prevention and treatment of watery mouth cases.

The inability of metoclopramide to prevent watery mouth as the lambing season progressed, especially in housed flocks, and the excellent results obtained when subsequently using amoxycillin suspension prophylactically, would suggest that the aetiology of watery mouth is multifactorial and that the level of environmental bacterial challenge is an important factor. Further studies using metoclopramide are planned to investigate this disease complex which is a major cause of economic loss to the sheep industry.

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